THURSDAY, AUGUST 17, 1899.

ENZYMES.

The Soluble Ferments and Fermentation. By J. Reynolds Green, Sc.D., F.R.S. Pp. xiv+480. (Cambridge University Press, 1899.)

PROBABLY no subject in the whole of the vast domain of biology exceeds this in interest, and certainly none transcends it in the importance of its bearings on the doings of the human race. The bread and cheese we eat, the beer and wine we drink, are entirely dependent on these ferments for their preparation; and the same is true of the processes of digestion which render their products assimilable into the plant or animal economy.

Then, have not Pasteur and men who have followed him made clear that the principle of fermentation lies at the root of an enormous class of diseases; aye, and demonstrated the truth of the doctrine by that most cogent of all arguments—experimental production of the disease from the use of the agents, and cure or prevention of it by the employment of the antidotes and therapeutic measures suggested by the scientific inquiry?

The making of jams, the tinning of preserved meats and fruits, the curing of hides and tanning of leather, and a hundred other branches of industry owe their successful pursuit to the intelligent application of the teachings of science; so clearly is this being recognised now, that it is becoming customary to speak of "fermentation industries" as a class. For it must no longer be supposed that brewing is the only fermentation industry; modern discovery in connection with dyeing, the curing of tobacco, the retting of flax, and many departments of agriculture show the necessity of extending the idea. Dr. Green's aim has been to collect all that is known of the study of those remarkable and curious bodies (Enzymes) which can be extracted from the protoplasm of living cells, can be precipitated mechanically from the solutions, and preserved as dry, impalpable powders, and still retain more or less unimpaired their astonishing powers of again bringing about decompositions of sugar, fats, proteids and other organic substances in solutions just as they could in the cell itself or in the waters outside the cell.

These powers are astonishing, because they are manifested so extensively by almost unweighably small quantities of the enzyme, and because they are exerted so smoothly and with such apparent ease and economy on bodies which we know to be very stable, and which can be artificially decomposed in similar ways only by the application of very energetic processes and very wastefully.

For it would seem that the study of fermentation is now the study of enzymes. Even the one sharply contrasted case—alcoholic fermentation—which Pasteur's classical labours appeared to place in a category apart from those of the enzymes, has come into line with the rest since Buchner's discovery that an enzyme-like body can be extracted from the cells of the yeast-plant, and can split up sugar into alcohol and carbon dioxide outside the living cell.

Very few authors have attempted the collection of the huge and ever-increasing mass of information scattered through the various journals devoted to special researches on fermentations, and the student had long been dependent on the now antiquated books of Schutzenberger and Naegeli for his summary of general views on the subject, until, in 1893, the extremely interesting but meagre brochure of Bourquelot came out to tantalise him with its disappointing sketch of recent progress. Now we can claim, from the hands of an English botanist, a comprehensive survey, which, whatever its few faults in detail, covers the enormous area admirably, and brings out the salient points and recent discoveries in a very satisfactory manner.

Until a few years ago, it was generally accepted that Pasteur's doctrine—fermentation is the result of life without oxygen—formed the corner-stone of the whole subject. The gradual recognition of the important parts played by the "soluble ferments," or *enzymes*, which, though their discovery dates from 1814, 1823, 1831, were not much studied before 1870, led to the further view that two categories of fermentation-processes must be distinguished, and the attempt was made by Naegeli and Sachs to uphold the idea that soluble or "unorganised" ferments (enzymes) act differently from "organised" or living ferments—*e.g.* bacteria, yeast-cells, &c.

Apart from other discrepancies, the fact that fermentations occur universally in higher plants and animals, as well as in lower organisms, rendered this view untenable, until the startling discovery by Buchner, in 1897, that a something of the nature of an enzyme can be extracted in water from the yeast-cell, which—outside the yeast-cell and quite independent of it—converts sugar into carbon dioxide and alcohol, may be said to have removed its last prop.

Although Lafar, in his remarkably able summary of the ferment-activity of the lower organisms, restricts the definition of fermentation to "transformations of matter . . . exclusively by the vital action of ferments," understanding by the latter word the living cells themselves, it is evident that we are here confronted with an entirely different definition of fermentation. Having abandoned successively the views that it is a phenomenon of life without oxygen, that it is confined to the protoplasmic activity of lower organisms, that there are two different categories of ferments—organised and unorganised, we are now threatened once more with the generalisation that fermentation is a purely chemical phenomenon due to the peculiar molecular activity of certain bodies formed, it is true, by protoplasm, but acting independently of it: a generalisation supported by Fischer's work on the constitution of the sugars, which he regards as so built up that an enzyme can only attack any particular sugar the molecular symmetry of which is related to its own, much as the wards of a lock can be overcome only by a key with a particular pattern.

Dr. Green gives us a very exhaustive account of the many various enzymes now known, classifying them under the following heads.

(1) Those which transform insoluble carbohydrates, producing soluble sugars—*e.g. Diastase* in germinating seeds and other plant-organs, which attacks starch;

Inulase, which decomposes inulin; *Cytase*, which hydrolyses cellulose.

(2) Those which transform more complex sugars into simpler compounds of the same class—*e.g.* *Invertase*, which attacks cane-sugar; *Glucase*, which splits up maltose, and others.

(3) Those which break up glucosides into some sugar and an aromatic body—*e.g.* *Emulsin*, which decomposes the amygdalin of almonds into sugar and prussic acid; *Myrosin*, which breaks up the sinigrin of mustard into a sugar and the pungent substance so well known.

(4) Proteolytic enzymes, such as *Pepsin* and *Trypsin*, which decompose insoluble and indigestible proteids into soluble and digestible peptones and other bodies, and play so important a part in digestive processes generally.

(5) The clotting enzymes which bring about coagulations—*e.g.* *Rennet*, so important in converting milk into cheese; *Thrombase*, the enzyme concerned in the coagulation of blood; *Pectase*, the chief agent in forming vegetable jellies.

(6) The *Lipases*, concerned in decomposing oils and fats.

(7) The *Oxydases*, a curious class of enzymes recently shown to be active in carrying oxygen and bringing about the oxidation of certain vegetable juices—*e.g.* *Laccase*, concerned in the formation of lacquer varnish.

(8) A number of enzymes as yet unclassified—*e.g.* *Urease*, which induces the formation of ammonium carbonate from urea, and the newly discovered "zymase" of Buchner—the alcohol producing enzyme.

It is, of course, impossible in a review to go far into particulars concerning these numerous forms, of which, moreover, there are many varieties. On reading Dr. Green's admirable and exhaustive account of them, the student will be struck with the prominent position which the study of plants occupies in the elucidation of the properties of enzymes. It has been far too fashionable in this country to regard enzymes and the study of fermentation as if they were in some way specially accredited to the domain of the chemist, whereas inasmuch as any such specialisation can be insisted upon, the study is far more within the domain of the botanist and the physiologist, a fact very clearly brought out in this book; as are also many of the important bearings of the study on the numerous applications of botanical science in the arts.

Secondly, it is worth remarking, in full view of the industrious and valuable work done by able continental botanists and physiologists, how conspicuous are the researches of English investigators in this department of science during the last few years, denoting a phase of activity on the part of our physiologists and botanists which promises well in the future. The author has collected a long list of authorities, and since he has made the study of fermentations peculiarly his own for some years, we may accept the literature as practically complete. At the same time, in view of the remarks on p. 75, we should have expected some quotation of Mr. Parkin's recent and important paper on the inulins in monocotyledons.

In view of the modernity of the study of enzymes, we can hardly be surprised at the lack of any complete deductive explanation of their action, though one of the most interesting sections of the book is that discussing the various hypotheses raised. Our ignorance of the constitution of enzymes no doubt stands at the bottom of this, and it is not at present clear what is meant by a soluble enzyme or by solution. But the fatal blocks to progress in the study of their constitution so far have been their instability during separation, and the uncertainty as to their purity; consequently the analyses so far attempted cannot be relied on, and we do not even know of any enzyme that it is proteid in nature. All we can be sure of is that a given watery extract washes out from living protoplasm a something—which we term an enzyme—which is capable of converting enormous masses of some other body—*e.g.* sugar—and can itself be mechanically precipitated, re-dissolved and so on. This precipitate may even be dried and retain its specific powers on re-solution. Whether the precipitate consists principally of the enzyme itself or of some body or bodies to which it is attached, is an unsolved question.

But when active and in solution, it is significant that the properties of an enzyme can be destroyed in a few moments by raising the temperature beyond a (relatively low) maximum, and that the activity rises and falls with a scale of temperature between the limits; on the other hand, it differs from a living organism in being capable of exerting its specific power in presence of an antiseptic.

In the discussion regarding fermentation as a chemical process, these facts should not be overlooked, and it is as true to-day as it was in Pasteur's time, that you cannot have fermentation without life.

No matter how "dead" an enzyme may be; no matter whether its remarkable energy consists in surface-actions or in vibrations propagated through the solution, in temporary chemical unions and disunions or in electrical hydrolysis; and no matter what its chemical analyses may imply as to its proteid nature—the fact must be maintained that enzymes are built up by living protoplasm, and normally exert their best actions in connection with the living cell. In many respects, indeed, they suggest essential bits of the protoplasm, and in many ways remind us that we have not yet done with the physiological or "vital" theory of fermentation, and this will, we think, strike most readers, though perhaps Dr. Green's summing up inclines more to the view that fermentation is a purely chemical process. Not the least important prop to the chemical theory of enzyme-action is furnished by Croft Hill's recent work on the action of maltase or glucase on malt-sugar, and his remarkable discovery that a reversal of the enzyme-action may occur, reminding us of the reversals occurring in certain chemical processes.

Here, however, we must stop. It is not necessary to recommend the perusal of the book to all interested in the subject, since it is indispensable to them, and we will merely conclude by congratulating the Cambridge Press on having added to their admirable series of Natural Science Manuals an eminently successful work on so important and difficult a theme, and the author on having written a treatise cleverly conceived, indus-

triously and ably worked out, and, on the whole, well written. At the same time, it should be pointed out that such a work was especially in need of a good and exhaustive index, and that it is a pity the author did not compile one himself.

CALCULATION BY ABACUS.

Traité de Nomographie. Par Maurice d'Ocagne. Pp. xiv + 480. (Paris: Gauthier-Villars, 1899.)

THIS is a book which ought to make even the ordinary reader appreciate the perennial freshness of mathematics. The method of "Nomography" (X3 of the international catalogue), recent as it is in its more important developments, is based upon a very simple idea which has long been familiar—that of the indexed scale. The ever-recurring problem of applied mathematics is to calculate an unknown numerical quantity from its relation to other quantities that are known. The simplest case is when two quantities x, y are connected by a relation $f(x, y)=0$ or $y=\phi(x)$. For practical purposes it is convenient to have a permanent record of a large number of corresponding values of x and y so that for any given value of x the approximate value of y may be at once found or obtained by simple interpolation. Three methods are available: the first is that of a numerical table, such as a table of logarithms; the second that of the graph, for instance the curve $f(x, y)=0$ or $y=\phi(x)$ referred to rectangular coordinates; the third is that of the indexed scale, that is to say a straight line or curve at different points of which the corresponding values of x and y are shown in figures. A familiar example is given by a thermometer with Centigrade and Fahrenheit readings, or by a measuring tape with centimetres marked along one edge and inches along the other.

In this very simple case the advantage of the indexed scale is not very obvious; even here, however, the method combines much of the vividness of the graph with a considerable saving of space. It is when three or more variables are connected by a relation that the great value of the scale method becomes apparent. Suppose, for instance, we have a relation

$$F\{\phi(x), \chi(y), \psi(z), \omega(t)\}=0$$

where x, y, z, t are the variables and $F, \phi, \chi, \psi, \omega$ are known functions. The essence of the nomographic function consists in first plotting off in a suitable way indexed scales of $\phi(x)$, $\chi(y)$, $\psi(z)$, $\omega(t)$, and then employing a linkage or similar mechanism to associate four corresponding values, $x' y', z', t'$. In the case of two variables x, y the "linkage" consists merely in the juxtaposition of the scales; when a proportion sum is done with a slide-rule, the scales are moved relatively to each other; in most of M. d'Ocagne's illustrations, involving several variables, the scales are either superposed in a two-dimensional grating or a movable linkage is used consisting of a transparent sheet with lines of reference ruled upon it, or a combination of both devices is employed.

Of course a method so elastic leaves ample room for ingenuity in constructing an "abacus," as M. d'Ocagne calls it, suited to any particular problem. The author gives an abundant variety of illustrations, many of great practical importance to the physicist and engineer: it is by studying these, and actually taking readings for himself, that the reader will succeed in appreciating the value of the method. For of this, as of other graphical methods, it may be said that merely reading it up, or understanding its principles in a general way, is of little use as compared with a thorough working knowledge of its application.

At the same time, M. d'Ocagne has done really good service in devoting his final chapter to the general theory. This has, in its way, the same kind of special value as Reuleaux's "Kinematics of Machinery" in relation to the ordinary treatises on mechanism. For in this chapter we have a clear conspectus of the general principles which underlie the construction of *any* abacus; and, what is still more remarkable, all possible varieties of abacus are classified into perfectly definite types which can be expressed by a simple abstract notation. Oddly enough, the enumeration of the different types leads to a difficult problem in the partition of numbers, happily solved by Major MacMahon.

It is not impossible that the human race may ultimately set off against the ravages of warfare the indirect stimulus which it has given to mathematics; nomography, at any rate, has been developed in great measure to meet the demands of civil and military engineering. M. d'Ocagne's numerous bibliographical notes will enable his readers to follow in detail, if they wish, the history of the subject. Pure and applied mathematicians alike will be grateful to him for a work so full of novelty and interest; while its subject-matter, as well as its clearness and simplicity, ought to make it eminently acceptable to the engineer.

G. B. M.

OUR BOOK SHELF.

Die Spiele der Menschen. By Karl Groos. Pp. vi + 538. (Jena: G. Fischer, 1899.)

PROF. GROOS will add by the present volume to the reputation he has already earned by his well-known work on the "Games of Animals." A really comprehensive account, at once sympathetic and intelligent, of the games of both children and adults has long been a desideratum with the psychologist as well as with the anthropologist, and Prof. Groos's new work goes very far indeed towards permanently supplying the want. As is only right and proper, by far the larger part of the book is given up to an exhaustive description of the facts as far as they are known; the "Theory of Play" enunciated in the second part of the treatise can thus be judged by the reader upon a sufficiently wide basis of empirical information. The range and the accuracy of Prof. Groos's knowledge are alike surprising; not only is he a mine of information about the amusements of his own country, but he appears, for instance, as much at home in the English nursery and playground as though he had been brought up amongst us. Almost the only signs of imperfect knowledge of English games to be detected in the whole book are the author's ascription of "Hare and Hounds," in its familiar form, exclusively to America, and his apparent ignorance of the continued vitality of "Hunt the Slipper." As a psychologist Prof. Groos is distinguished by a singular subtlety of discrimination; his account, for instance, of the various elements which enter into the gambler's enjoyment of high play, or, again,

of the combination of "the pleasure of intense stimulus" and the "pleasure of conflict" in our enjoyment of a tragedy, are models of delicate æsthetic analysis. The author's attitude towards the various current theories of "play" is eminently judicious. As he well points out, both the "surplus activity" theory and the "recreation" theory are one-sided, the former doing less than justice to the pastimes of adults, the latter to those of children. His own view that play must be regarded by the biologist primarily as the great educator and perfecter of imperfect instincts has been most nearly approached by Prof. Baldwin. Prof. Groos's treatment of the sociclogical aspects of "play," both as the child's earliest form of experimentation and as the earliest school of obedience to authority, should prove useful to students of ethics as well as to professed sociologists. The admirable literary style of the book, no less than the interest of its contents, should recommend it to all persons of general culture who care for anthropological studies. A. E. T.

Physique et Chimie Viticoles. By A. de Saporta. Pp. iv + 300. (Paris: G. Carré and C. Naud, 1899)

IN the preface to this book, contributed by M. P. P. Dehérain, the immense importance of the vine culture to France is pointed out, the wine from the department of Hérault alone having in 1897 a value of 212,000,000 francs. The questions of suitability of soil, of manures, of the remedies against the many diseases of the vine, of fermentation, and preservation of wine all depend largely upon simple chemical and physical considerations; hence arises the necessity for such a work as the present, dealing with the physics and chemistry of vine culture and wine production. Of the eight chapters composing the book, the first two are preliminary, giving a very brief outline of the atomic theory and the measuring instruments used in the laboratory. The third chapter deals with the soil, especial attention being directed to the use of various insecticides, and to the causes of vine disease generally residing in the soil. In the third chapter, on account of the importance of the estimation of calcium carbonate in the soil, numerous calcimeters are described, some of considerable and apparently unnecessary complexity, as, for example, the self-registering calcimeter of Houdaille. The description of the properties of manures is lucid, and their analysis is treated in a simple manner. Chapter vi., dealing with the remedies for vine diseases, is, on account of the evident practical knowledge of the author, the most valuable portion of the book. The number of remedies that have been invoked to combat mildew, black rot, chlorosis, phylloxera, and other vine diseases, is so great as to render their classification and intelligent use difficult. Especial attention is here directed to the use of carbon bisulphide, ferrous sulphate, sulphur, copper sulphate and acetate, and mercury salts, the last-named being emphatically condemned in spite of their undoubted efficacy in combating fungoid diseases. The concluding chapters deal briefly with the fermentation of the grape, analysis of the wine, and the diseases to which it is liable. The book will be of great practical service to vine growers.

Cours Élémentaire de Zoologie. Par Remy Perrier. Pp. 734. 697 illustrations. (Paris: Masson et Cie., 1899.)

THIS work contains a great deal in brief that is to be found in its predecessor, the author's "Éléments d'Anatomie Comparée," published in 1893. In some respects it may be said to be a "Grundriss" to that volume, but, in contradistinction to it, the Vertebrata are here treated on a greater equality with the Invertebrata, and the order of presentation is more rational and in accordance with precedent. For example, the Chætopod Worms are dealt with before the Arthropods, the inversion of this order being a notorious feature of the "Éléments." Chapter i. is devoted to broad principles and definitions, Chapter ii. to the elements of histology, and Chapter iii. to the classification of the metazoa—177 pp. in all. Tables of affinity and structural relationship are here and there given, and the 565 remaining pages of the work are devoted to a systematic consideration of each of the greater groups of animal forms in an ascending order, the Echinoderms, Rotifers, Polyzoa, and Brachiopods being taken after the Cœlenterates and before the Leeches and Worms. Some of the groups receive but scanty treatment, meagre and wholly insufficient, and throughout the work the author has conspicuously neglected the rendering clear the extremes of modification of the great groups, which we consider should be an indispensable feature of an elementary text-book on organic forms that shall do justice to our present knowledge. In dealing with such an assemblage as the Tunicata, where octoradiate, valved, stalked, and many other well-known forms occur, a great opportunity has in this way been lost, and the same may be said of the author's treatment of the Bryozoa.

The illustrations are for the most part good and clear; some of the new ones are admirable, and we congratulate the author upon such as his aortic arch series (p. 602), which are the most accurate and up to date of any text-book set yet published. They are sure to be popular and reproduced *ad nauseam*. But why that old nightmare the Cuvier's "Chimæra" (Fig. 589), a badly drawn Chimæra with a Callorhynchus tail! Surely the time has come when this and other persistent atrocities of our text-books, which have so long offended, should be condemned.

A really sound elementary treatise on zoology has long been a desideratum, and the present work is the outcome of a commendable attempt to supply the need. Though desperately thin in parts it is up to date in its leading themes, well arranged, and written in a good easy style, and it may be safely recommended as trustworthy so far as it goes.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Thermometric Scales for Meteorological Use.

IN the course of some recent work on the meteorology of Ben Nevis, which involved extensive extracting and computing work, I have again had forcibly impressed on me the great advantage which Fahrenheit's thermometer has over that of Celsius for meteorological use, especially in temperate regions.

In chemistry and physics the range of temperature covered is so great that Celsius' scale, which is now universally used, adequately meets every case. The size of the degree and the change of sign at the melting point of ice do not cause any inconvenience in the laboratory. It is otherwise in the meteorological observatory. There the range of temperature dealt with is very restricted, and the Celsius degree is too large, while the change of sign in the middle of the working part of the scale is simply intolerable. The latter peculiarity is the fruitful introducer of error into both the observations and the reductions, and besides it greatly increases the fatigue of both classes of work.

In view of the agitation to abolish the use of Fahrenheit's scale, and to replace it universally by that of Celsius, it may not be inopportune to direct attention to some of the advantages in securing accuracy and in relieving labour which Fahrenheit's scale offers over that of Celsius when used for meteorological purposes.

In tropical countries it matters little whether one scale or the other is used, except that the size of Fahrenheit's degree is much

the more convenient, as the first decimal place is always sufficient. But in Europe and in North America, where the greater number of meteorological observatories is situated, the temperature falls every year below the freezing point of water. In some localities it passes quickly through this point and remains constantly below, often far below it, returning again in the spring and passing as quickly through it again in the beginning of summer, to remain constantly above it until it drops away again in the fall of the year In such places, where, however, the population affected is limited, the use of Celsius' scale is not open to very much objection. With the exception of a few days in the fall, and again in the spring of the year, the temperatures are either continuously positive or continuously negative; and during one-half of the year the observer reads his thermometer upwards, while during the other half of the year he reads it downwards. When he has got well into the one or the other half of the year, he will make no more errors than those that he is personally liable to under circumstances of no difficulty. But at and near the two dates when the temperature is falling or rising through that of melting ice the case is very different. If the rise or fall is rapid, his task is comparatively easy, and, after a few unavoidable mistakes, he has succeeded in inverting his habit of reading. But, in those parts of Europe and North America which carry nearly the whole of the population, the temperature in winter is frequently oscillating from one side to the other of the melting point of ice. If the observer is compelled to use a thermometer which he must read upwards when the temperature is on one side of that point, and downwards when it is on the other side, and if he may be called on to perform this fatiguing functional inversion several times in one day, it is certain that he will suffer from exhaustion, and that the observations will be affected with error.

Were there no other thermometric scale available but that of Celsius, we should simply have to put up with it, and endure the inconvenience of it; but, when we have another scale, one devised primarily for meteorological observations in the North of Europe, by a philosopher who constructed it with a single eye to its fitness for what it was to be called upon to measure, and when, in addition, this scale is still exclusively used in a large proportion of the meteorological observatories of the world, it seems almost incredible that amongst reasonable people, be they scientific or non-scientific, there should be a powerful agitation to abolish the scale which was devised for its work, which excludes error in so far as it can be excluded, and to replace it by one which, besides other defects, introduces, in the nature of things and of men, *avoidable* errors, the elimination of which is the first preliminary of the scientific treatment of all observations in nature.

Every meteorologist in northern countries who makes use of the data which he collects knows that when his temperatures are expressed in Fahrenheit's degrees, he can discuss them at much less expense both of labour and of money for computing than when they are expressed in Celsius' degrees; yet such is the apprehension of even scientific men when brought face to face with the risk of being ruled "out of fashion," that meteorologists who use Fahrenheit's scale, though they fortunately do not give up its use, seem to be disabled from defending it.

What is this stupefying fashion, and can it not be made our friend?

Fahrenheit lived and died before the decimal cult or the worship of the number ten and its multiples came into vogue; but, whether in obedience to the prophetic instinct of great minds or not, it almost seems as if he had foreseen and was concerned to provide for the weaknesses of those that were to come after him. The reformers of weights and measures during the French revolution rejected every practical consideration, and chose the new fundamental unit, the metre, of the length that it is, because they believed it to be an exact decimal fraction one ten-millionth of the length of the meridian from the pole to the equator. Is it an accident that mercury, which was first used by Fahrenheit for filling thermometers, expands by almost exactly one ten-thousandth of its volume for one Fahrenheit's degree?

Again, how did Fahrenheit devise and develop his thermometric scale? A native of Danzig and living the first half of his life there, he considered that the greatest winter cold which he had experienced in that rigorous climate might, for all the purposes of human life, be accepted as the greatest cold which required to be taken into account. He found that this temperature could be reproduced by a certain mixture of snow and salt. As a higher limit of temperature which on similar grounds he held to be the highest that was humanly important, he took the temperature of the healthy human body, and he subdivided the interval into twenty-four degrees, of which eight, or one-third of the scale, were to be below the melting point of pure ice, and two-thirds or sixteen were to be above it. Fahrenheit very early adopted the melting temperature of pure ice for fixing a definite point on his thermometer, but he recognised no right in that temperature to be called by one numeral more than by another. The length of his degree was one-sixteenth of the thermometric distance between the temperature of melting ice and that of the human body, and the zero of his scale was eight of these degrees below the temperature of melting ice, and not, as is often thought, the temperature of a mixture of ice and common salt or sal-ammoniac. Fahrenheit, as has been said, was the first to use mercury for filling thermometers; and being a very skilful worker, he was able to make thermometers of considerable sensitiveness, on which his degrees occupied too great a length to be conveniently or accurately subdivided by the eye. To remedy this he divided the length of his degree by four, and the temperature from the greatest cold to the greatest heat which were of importance to human life came to be subdivided into 96 degrees.

Had he lived in the following century he would have been able to point out that on his scale the range of temperature within which human beings find continued existence possible is represented by the interval 0 to 100 degrees, and there can be little doubt that this would have secured its general adoption. Its preferential title to the name Centigrade is indisputable. Perhaps this may be an assistance to its rehabilitation as the thermometer of meteorology. J. Y. BUCHANAN.

Cambridge, August 4.

On the Deduction of Increase-Rates from Physical and other Tables.

THE problem treated by Prof. Everett in your issue of July 20, p. 271, allows a somewhat simpler solution. Take the example given by Prof. Everett. To find the value of $\frac{dp}{d\theta}$ at the temperature 105°, we have only to consider the columns for Δp, $\Delta^3 p$, $\Delta^5 p$, &c. In each of these columns there are two numbers, one just above and one just below the horizontal line, corresponding to the value $\theta = 105°$. In the column for Δp, for instance, these two numbers are 408 and 470, in the column for $\Delta^3 p$ they are 5 and 8 If now m_1, m_3, m_5, &c., are the means of each of these two numbers, so that in this case $m_1 = 439$, $m_3 = 6.5$, we have:

$$\frac{hdp}{d\theta} = m_1 - \frac{m_3}{2.3} + \frac{m_5}{2.3.4.5} 2^2 - \frac{m_7}{2.3.4.5.6.7} 2^2 3^2 + \ldots$$

If p be capable of being expressed in the form $A + B\theta + C\theta^2$ only the first term m_1 is required; if

$$p = A + B\theta + C\theta^2 + D\theta^3 + E\theta^4$$

only the first two terms $m_1 - \frac{m_3}{2.3}$ are required, and so forth. In these cases the solution is exact, whereas in general the method gives only approximations closer and closer the more terms are added.

The difference between my solution of the problem and Prof. Everett's is only formal. It may readily be seen that in Prof. Everett's notation

$$2m_1 = d_1 + u_1,\ 2m_3 = d_2 - u_2,\ 2m_5 = (d_3 + u_3) - (d_2 - u_2),$$

which makes his equations special cases of my expression for $\frac{hdp}{d\theta}$. The proof of my expression may be given by the calculus of finite differences. For simplicity let us write $x = \theta - 105°$, and let us develop the function p in the form:

$$p = a_0 + a_1 x + \frac{a_2}{2} x(x-h) + \frac{a_3}{2.3}(x+h)x(x-h) + \ldots$$

General terms:

$$\frac{a_{2n}}{2.3.4 \ldots 2n}(x+(n-1)h) \ldots x \ldots (x-nh)$$

$$+ \frac{a_{2n}+1}{2.3.4 \ldots 2n+1}(x+nh) \ldots x \ldots (x-nh)$$

By the calculus of finite differences we obtain :

$$\frac{\Delta p}{h}=\frac{p(x+h)-p(x)}{h}=a_1+a_2x+\frac{a_3}{2}(x+h)x+\frac{a_4}{2.3}(x+h)x(x-h)+\dots$$

and

$$\frac{\Delta^2 p}{h^2}=a_2+a_3(x+h)+\frac{a_4}{2}(x+h)x+\frac{a_5}{2.3}(x+2h)(x+h)x+\ \dots$$

Therefore :

$$ha_1=\Delta p \text{ for } x=0 \text{ and } h^2a_2=\Delta^2 p \text{ for } x=-h$$

By proceeding in the same way we find $h^{2v}a_{2v}=\Delta^{2v}p$ for $x=-vh$ and $h^{2v+1}a_{2v+1}=\Delta^{2v+1}p$ for $x=-vh$.

The value of $\Delta^{2v}p$ for $x=-vh$ is the number in the column for $\Delta^{2v}p$, which stands in the horizontal line corresponding to the stated value of θ (105 in our case), while the value of $\Delta^{2v+1}p$ for $x=-vh$ is the number in the next column just below this line. The mean of this number and the one above it we have before denoted by m_{2v+1}; we now add the notation m_{2v} for the value of $\Delta^{2v}p$ for $x=-vh$. As m_{2v+2} is the difference of the two numbers, whose mean is m_{2v+1}, we can write $m_{2v+1}+\frac{1}{2}m_{2v+2}$ instead of the value of $\Delta^{2v+1}p$ for $x=-vh$.

We have therefore :

$$a_{2v}=m_{2v}h^{-2v}$$

and

$$a_{2v+1}=(m_{2v+1}+\tfrac{1}{2}m_{2v+2})h^{-2v}.$$

Substituting these values in the expression for p we have :

$$p=a_0+(m_1+\tfrac{1}{2}m_2)\frac{x}{h}+\frac{m_2}{2}\frac{x(x-h)}{h^2}$$
$$+\frac{1}{2.3}(m_3+\tfrac{1}{2}m_4)\frac{(x+h)x(x-h)}{h^3}+\ \dots$$

General terms :

$$\frac{1}{2.3\ \dots\ 2v+1}(m_{2v+1}+\tfrac{1}{2}m_{2v+2})(x+vh)\dots x\dots(x-vh)h^{2v-1}$$
$$+\frac{1}{2.3\ \dots\ 2v+2}m_{2v+2}(x+vh)\ \dots\ x\ \dots\ (x-vh)$$
$$(x-(v+1))h^{-2v-2}.$$

To find the value of $\frac{dp}{d\theta}$ we now need only differentiate according to x and make x equal zero.

Thus we obtain :

$$h\frac{dp}{d\theta}=(m_1+\tfrac{1}{2}m_2)-\frac{m_2}{2}-\frac{1}{2.3}(m_3+\tfrac{1}{2}m_4)+\frac{1}{2.3}\frac{m_4}{2}+\ \dots$$

General terms :

$$\frac{(-1)^v}{2.3\ \dots\ 2v+1}(m_{2v+1}+\tfrac{1}{2}m_{2v+2})2^2\,.\,3^2\ \dots\ v^2$$
$$+\frac{(-1)^{v+1}}{2.3\ \dots\ 2v+2}m_{2v+2}\,.\,(v+1)\,.\,2^2\,.\,3^2\ \dots\ v^2;$$

or by contracting two consecutive terms :

$$h\frac{dp}{d\theta}=m_1-\frac{1}{2\cdot 3}m_3+\frac{1}{2\cdot 3\cdot 4\cdot 5}m_5\,.\,2^2-\ \dots$$

The second differential coefficient is found in a similar way. It is only necessary to observe that the second differential coefficient of $(x+vh)\ \dots\ x\ \dots\ (x-vh)$ vanishes for $x=0$ and that of $(x+vh)\ \dots\ x\ \dots\ (x-(v+1)h)$ is equal to $2\,.\,(-1)^v\,.\,2^2\,.\,3^2\ \dots\ v^2h^{-2v}$. Therefore we obtain

$$h^2\frac{d^2p}{d\theta^2}=m_2-\frac{2}{2\cdot 3\cdot 4}m_4+\frac{2}{2\cdot 3\cdot 4\cdot 5\cdot 6}\,.\,2^2\,.\,m_6-\ \dots$$

General term :

$$\pm\frac{2}{2\cdot 3\cdot 4\ \dots\ 2v+2}2^2\cdot 3^2\ \dots\ v^2\,.\,m_{2v+2}.$$

Hannover, Technische Hochschule. C. RUNGE.

PROF. RUNGE'S proof is longer and more difficult than mine; but his result is in simpler shape, and possesses the great merit of giving the successive approximations as the terms of a regular series. J. D. EVERETT.

22 Earl's Court Square, July 28.

The So-called "Thunder"-storm.—Prevalence of Anticyclones.

IT must have occurred to others besides myself how very absurd it is to designate a meteorological phenomenon by the least important of its characteristics, viz. the noise it makes. We never speak of a hail-storm as a "rattle"-storm, or a shower of rain as a "patter"-storm; why then should we call an electrical disturbance a "thunder"-storm? Thunder, though no doubt terrifying to savages and children and old ladies (one or two of whom have, I believe, been killed by the fright of it), and though of some interest as an acoustic phenomenon, is absolutely the most trivial of the accompaniments of an electrical discharge.

It would seem hopeless to eradicate the childish term entirely from popular language, but surely in the scientific reports and forecasts issued by the Meteorological Office, and in scientific literature generally, the term "electric storm" (or disturbance) might replace "thunderstorm."

With regard to the late prevalence and persistence of anticyclonic conditions over the centre and south of our islands, I wish to suggest that it may be connected with the unusual extension southwards of the Polar ice-pack this summer. I saw it stated about a month ago that even Spitsbergen was then surrounded by ice, most of the fiords being quite inaccessible. When I was there in July 1896 we could only just see the blink of the pack in the north horizon.

Now, it is an ascertained and easily intelligible fact that areas of cold (water or ice) on the earth's surface have a tendency to cause the formation of areas of high pressure or dense air in the atmosphere above them. The result would be, not only a prevalence of anticyclones in high latitudes over the North Atlantic, but also the persistent extension of the northern edge of the great "Atlantic anticyclone" over the south and centre of England (attracted, as it were, by the high pressure in the north); so that cyclones which usually strike the south-west of Ireland or the coast of Cornwall have been "fended off" to the north of Scotland, with the result of heat and drought over England.

I only put this forward as a suggestion, and I should be glad if any of your Icelandic or Norwegian readers would supply details of the position of the Polar ice-pack, temperature of the sea in the North Atlantic, &c., for I have learnt to mistrust all statements appearing in those interesting, and often sensational, works of fiction—the daily papers. METEOR.

August 12.

Scoring at Rifle Matches.

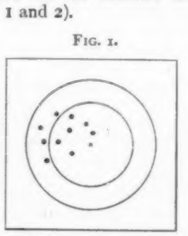
WHILE the Bisley meeting is still fresh in the memory of those interested in rifle shooting, it seems worth while to call attention to the rather unsatisfactory nature of the method of scoring now in general use.

What brings the matter into special prominence is the large number of "best possibles" always made in recent years.

With a satisfactory system of scoring such a phrase ought only to apply when every shot passes through the same hole in the centre of the bull's-eye.

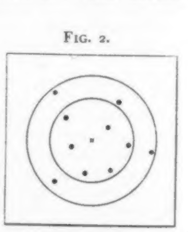
The present practice, however, gives the same number of marks to shooting of widely differing merit, and this must always be the case as long as the result is made to depend on the distance of each shot from the centre of the target, irrespective of the distance of the shots from one another (see Figs. 1 and 2).

FIG. 1.



Ordinary score 46.
By moment of inertia 24·5.

FIG. 2.



Ordinary score 46.
By moment of inertia 18.

The merit of any series of shots really depends on two elements, namely, the distance of the average direction of the whole series from the centre of the target and the compactness with which the individual shots are grouped about that direction.

The importance to be assigned to each of these elements may vary with the object for which the shooting is undertaken, but a knowledge of both is essential in estimating its quality.

If the object be to get all the shot as near the centre of the target as may be, the same importance should be attached to close grouping as to the mean direction, as will be shown further on.

Since any practical method of scoring must be rapid and easily understood by people who are not mathematical, it would probably be asking too much if it were proposed to treat each result in an accurate manner, simple though the required arithmetic is; but some modification of the accurate method could probably be made sufficiently simple for general use, which would give a much truer estimate of the goodness of the shooting than that now in use.

The accurate plan of estimating the value of any series of shots consists, in mathematical language, of finding the distance of the centre of gravity of the group from the centre of the target, and taking the radius of gyration of the group about its centre of gravity. The goodness of the shooting will then be measured by the reciprocal of the sum of the squares of these quantities, each multiplied by a constant, and it will presently be shown that if, as in an ordinary match, the object is to hit the centre of the target, these constants are equal.

A convenient way of finding the centre of gravity and radius of gyration is to have the target divided into 100 squares by eleven vertical and eleven horizontal lines (see Fig. 4), the position of the shot being recorded by naming the square through which it passes; (for instance, a shot in the fourth vertical row and fifth horizontal row would be recorded as 4·5).

If we call the number of the vertical row x, and the number of the horizontal row y, very simple algebra will prove—in fact, it is obvious—that for a series of n shots the coordinates (h . k) of square containing the centre of gravity of the shots will be

$$h = \Sigma x/n \quad k = \Sigma y/n,$$

where Σx denotes the sum of all the x's, and Σy denotes the sum of all the y's.

Since the score does not record the position of an individual shot with greater accuracy than the width of a single square this is equivalent to the assumption that each shot passes through the centre of the square it hits, and that the origin of the coordinates is in the centre of the square at o (off the target) (see Fig. 4).

Thus the coordinates of the centre of the target will be

$$x = 5{\cdot}5 \quad y = 5{\cdot}5,$$

and the distance of the centre of gravity from the centre of the target is

$$R = \sqrt{(\Sigma x/n - 5{\cdot}5)^2 + (\Sigma y/n - 5{\cdot}5)^2}.$$

The radius of gyration of the group about an axis normal to the plane of the target, and passing through the centre of gravity is

$$\rho = \sqrt{\Sigma x^2/n - h^2 + \Sigma y^2/n - k^2}.$$

To examine the relative importance of the closeness of the shots to one another and the distance of their mean from the centre of gravity, consider the effect of slightly varying each of the quantities R and ρ.

The question to be answered is: "If of two groups one is represented by R and ρ, and the other by $R + dR$ and $\rho - d\rho$, which gives evidence of the best shooting?"

In Fig. 3 let C be the centre of the target, and G the centre of gravity of the group, and P Q R a circle described with radius ρ about G, so that $CG = R$, $GP = \rho$; then if $CGP = \theta$, the distance (r) of P from C is

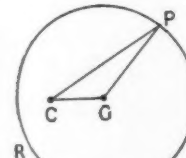


FIG. 3.

$$r = \sqrt{R^2 - 2R\rho\cos\theta + \rho^2},$$

differentiating with respect to R and ρ, we have

$$\frac{dr}{dR} \Big/ \frac{dr}{d\rho} = -\frac{\rho - R\cos\theta}{R - \rho\cos\theta};$$

and integrating this with respect to θ from π to o we have for the relative mean values of dr, caused respectively by alterations of dR and $-d\rho$ in the values of R and ρ,

$$\left\{\int_0^\pi \frac{dr}{dR} \Big/ \int_0^\pi \frac{dr}{d\rho}\right\} d\theta = \frac{\rho}{R}.$$

If the two groups are equally good, the mean value of dR must be equal to minus the mean value of $d\rho$.

This leads to a simple relation between R and ρ, viz. $R^2 + \rho^2$ = constant. Thus any group of shots for which the sum of the squares of the mean distance of the group from the centre and its radius of gyration is constant is equally good.

This may be stated more concisely by saying that when the object is to hit the centre of the target, the merit of any series of shots is inversely proportional to its moment of inertia of the group about the centre of the target.

If for convenience it is decided to make the score 100 when the moment is unity, the worth of any given series will be represented by

$$\frac{100}{R^2 + \rho^2}.$$

I give below an actual target with the results analysed in the way described.

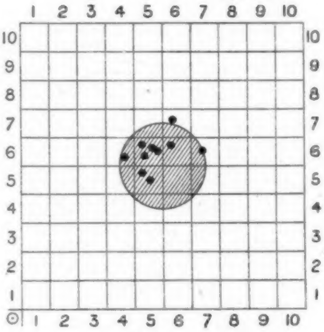
If a slide rule is used, the arithmetic takes about five minutes.

I do not for a moment suppose that such an analysis would be practicable at ordinary rifle matches, but it does seem possible that coordinate targets might become popular, and some simple way devised of using the more precise information they would afford.

As far as finding the moment of inertia of the group about the centre of the target is concerned, this might be done more simply by the use of polar coordinates, only the mean square of the distance from the centre being wanted for that purpose; but the Cartesian coordinates are more convenient when the closeness of the grouping has to be considered.

EXAMPLE.

Coordinate Target. Ten shots at 100 *yards. Target* 10 *inches square.*



Shot	Score X	Score Y
1	5	6
2	4	6
3	5	5
4	5	6
5	6	7
6	7	6
7	5	6
8	6	6
9	5	6
10	5	5

FIG. 4.

To analyse the score it is convenient to arrange the results in the following form; p and q being the number of shots on each vertical and horizontal row.

x	p	px	y	q	qy	px^2	qy^2
1	—	—	1	—	—	—	—
2	—	—	2	—	—	—	—
3	—	—	3	—	—	—	—
4	1	4	4	—	—	16	—
5	6	30	5	2	10	150	50
6	2	12	6	7	42	72	252
7	1	7	7	1	7	49	49
8	—	—	8	—	—	—	—
9	—	—	9	—	—	—	—
10	—	—	10	—	—	—	—

$$\frac{\Sigma x}{n} \quad 5{\cdot}3 \qquad \frac{\Sigma y}{n} \quad 5{\cdot}9 \qquad \frac{\Sigma x^2}{n} \quad 28{\cdot}7 \qquad \frac{\Sigma y^2}{n} \quad 35{\cdot}1$$

$$\frac{\Sigma x}{n} - h = 5{\cdot}5 \qquad \frac{\Sigma y}{n} - k = 5{\cdot}5 \qquad \left(\frac{\Sigma x}{n}\right)^2 \quad 28{\cdot}1 \qquad \left(\frac{\Sigma y}{n}\right)^2 \quad 34{\cdot}7$$

$$-{\cdot}2 \qquad {\cdot}4 \qquad {\cdot}6 \qquad {\cdot}4$$

$$.6$$

$$R^2 = ({\cdot}2)^2 + ({\cdot}4)^2 = {\cdot}2 \qquad \rho^2 = 1{\cdot}0$$

This counts $\frac{100}{1 + 2{\cdot}2}$ or 84.

A. MALLOCK.

ON SPECTRUM SERIES.[1]

WE have now, I trust, obtained a general idea of inorganic evolution so far as stratigraphic geology is concerned. You may remember that I pointed out that the evidence for organic evolution not only depended upon the various vegetable and animal forms which had been found in the various strata of the earth's crust from the pre-Laurentian up to the Recent times, but that the science of embryology had also been brought into play, and that a succession of forms in the individual was there to attest the general line of descent. To-night we have to deal with the spectroscope and the motions of the smallest units of inorganic matter which we can get at, and to compare the results obtained in this way with some of those that the biologist has arrived at by means of the microscopic examination of the smallest unit forms that he can observe. From the spectrum point of view, this inquiry is included in the word "series." In the study of series of lines in different spectra, we are on the same ground plan as the biologist is when he is studying what he calls cytology, or the laws of cells.

To explain what is meant by "series" I will refer to one or two photographs of what are termed fluted spectra. You will observe that such a spectrum is perfectly rhythmic from end to end. The whole of a fluting may be regarded as a unit; it is generally strongest towards the right or the red end of the spectrum, its elements gradually becoming dimmer as we approach the violet end. But a fluting is generally more than this; it is built up of subsidiary flutings. Each of the subdivisions of it is in itself an almost exact representation in the small of what the whole thing is in the great; so that we have the conceptions of a simple fluting and a compound fluting. The compound flutings are well represented in the flu tings of carbon. It is by means of such photographs that the existence of carbon in the sun has been determined. Each of the finer lines in one of the first elements of the compound fluting has a dark line corresponding with it among the Fraunhofer lines. In the case of the spectrum of nitrogen we get the same exquisite rhythm, the same intensification of the series of lines towards the red, and the same division of some of the larger flutings into smaller divisions; so that, as I said before, we have to consider flutings really as compound and not as simple phenomena. When we leave these flutings and study an ordinary line spectrum, in a great many cases all rhythm seems to have disappeared. There is apparently no law and no order. Let us take the lines seen when we expose the gases obtained from the mineral cleveite to the action of an electric current.[1] We observe that all rhythm has gone, and there seems to be a very irregular distribution; but when we come to sort those lines out into series, we find that there is just the same exquisite order that we get in the case of the flutings. You notice in the photograph all the lines higgledy-piggledy, the next photograph will show that they have all been resolved into two sets of three series which very much resemble those that we saw before; that is to say, they gradually get nearer together towards the violet, and they all get stronger towards the red. We have then two constituents of the cleveite gases, asterium and helium, and we find that their irregular line spectra when analysed into these series are translated into a wonderful order. I suggested many years ago that the lines in the ordinary line spectrum of a substance may really be remnants of compound flutings, and such inquiries as those that I have to refer to to-night really seem to justify that suggestion. Very well, then, we arrive at the fact that the term "series" is one employed to related lines. It is impossible to suppose that these wonderful rhythmic series of lines are not related in some way to each other, and that being so we have to study their wave-lengths, that is, their positions in the case of any one element; and not only so, but to see if any relation exists between the lines of different elements.

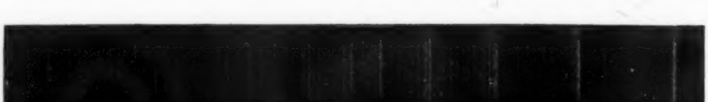


FIG. 1.—Compound flutings of carbon.

FIG. 2.—Simple flutings of nitrogen.

The history of this quite modern inquiry is not very long, but short as it is I only propose to refer to it in the briefest possible manner.

The first attempt to discover regularities in the lines of spectra was made by Lecoq de Boisbaudran,[2] who investigated the spectrum of nitrogen. The conclusions he arrived at suggested that the luminiferous vibrations of the molecules could be compared with the laws of sound, but as these were not based on wave-length determinations of sufficient accuracy, and also were not confirmed by Thalén, no great weight could be attached to the result.

Stoney,[3] who followed up these investigations, was more successful; he showed that the hydrogen lines C, F, and *h* were connected by the relationship 20 : 27 : 32.

Several other workers—Reynolds, Soret, &c.—took the subject up, but it was left for the more thorough work of Schuster[4] to show that this theory could no

[1] A Lecture to Working Men delivered at the Museum of Practical Geology, on May 1, by Prof. Sir Norman Lockyer, K.C.B., F.R.S.

[1] It has always been customary with me in reproducing spectra in the form of illustrations to show the red end of the spectrum on the right hand side and the violet end on the left. As most of the workers on "series" have adopted the opposite way, I propose *in this lecture* to depart from my usual custom and place the red in series spectra on the left, so that all the series illustrations may be comparable *inter se*.

[2] *Comptes rendus* (1869), 69, 694.

[3] *Phil. Mag.*, 1871 [4], 41, 291.

[4] Brit. Assoc. Report, 1880; *Proc. R.S.* (1881), 31, 337.

longer be considered as expressing the law connecting the mutual relationships between the wave-lengths of lines in a spectrum.

Liveing and Dewar[1] next called attention to the fact has extended. They have attacked the question mathematically from different standpoints. In the following table I give the formula employed by Kayser and Runge, and that employed by Rydberg.

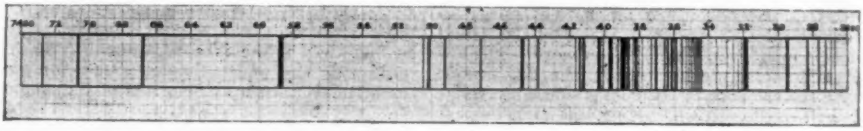


FIG. 3.—Spectrum of the Cleveite gases.

that the distance between two consecutive lines of these groupings decreases with diminishing wave-lengths, so that eventually the lines asymptotically approach a limit. "Harmonic" was the term they used to express such a series of similar groups of lines.

It was, however, the work of Balmer which gave the subject the impetus by which it has of late years made great progress.

Balmer[2] published a formula by which the positions of the hydrogen lines could be calculated with wonderful accuracy. The formula is as follows :—

$$\lambda = A\frac{n^2}{n^2-4},$$

in which λ is the wave-length in vacuo of the line to be calculated, A a constant common for all the lines, and n one of a series of numbers from 3 to 15.

The constant A, according to Cornu's measurements, is 3645·42 Ångstrom units, or, using Ames' more correct value, 3647·20 Ångstrom units.

Simultaneously with Balmer's discovery, Cornu[3] pointed out that the lines of aluminium and thallium, which are readily reversible, bear a definite relation to those of hydrogen, while at a later date Deslandres[4] published a formula from which could be calculated the wave-lengths of the lines composing the bands of numerous elements.

The above brief history brings us down to the year 1887, in which Kayser and Runge[5] began their series of minute investigations dealing with a great number of

Formulae for Calculating Series.

Kayser and Runge	Rydberg.
$\frac{1}{\lambda} = A + Bn^{-2} + Cn^{-4}$ where λ = wave-length (or $\frac{1}{\lambda}$ = wave frequency) $n = 3, 4, 5, \ldots$ A, B, C = constants calculated for each series. The constants for the principal series are different from those used in the subordinate series. For sub-series of Na, K, Rb, Cs, Cu, Ag, Al, In, and Tl, the constants B and C are identical. For all series the constant B does not vary by more than 22 per cent. This constant B corresponds to Rydberg's N_0.	$n = n_0 - \frac{N_0}{(m+\mu)^2}$ where n = wave frequency $m = 1, 2, 3, \ldots$ N_0 = 109721·6 (a constant applicable to all series of every element) n_0, μ = {characteristic constants varying with each series. In the above formula, when $m = \infty$, $n = n_0$; or n_0 is the limit which the number of waves n approaches when m is infinite. The value of N_0 is assumed by Rydberg to be constant, as it varies only slightly, and this variation may be due to uncertain data.

You will see that they are not by any means identical, but both deal with wave frequency, that is to say, the

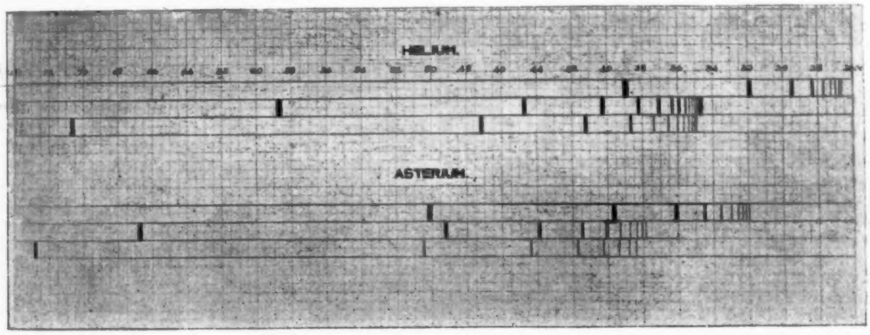


FIG. 4.—Spectrum of the Cleveite gases sorted out into six regular series.

elements. It was also about this time that Rydberg[6] commenced to take up the subject.

I will state generally the ground over which their work number of waves in a given unit of length. Then they employ a certain sign, n, to represent the successive integers which have to be used to define certain of their terms, and in addition to this we get certain constants which are calculated for each series. The most interesting consideration from this point of view is that Rydberg found that there was one constant which he could use in order to search for the series of lines in the spectra of all the chemical elements with which he worked. There was no common constant similar

[1] *Phil. Trans.*, 1883, p. 213, and previously.
[2] *Wied. Ann.* (1885), 25, 80.
[3] *Comptes rendus* (1885), 100, 1181.
[4] *Ibid.* (1886), 103, 375; (1887), 104, 972.
[5] "Ueber die Spectren der Elemente" (*Abhandlungen d. K. Akad. Berlin*, 1880, 1889, 1890, 1891, 1892, 1893.
[6] *Svenska Vetenskap. Akad. Handlingar*, Stockholm (1890), 23, No. 11; *Wied. Annalen* (1893), 50, 629; (1894), 52, 119.

to this used by Kayser and Runge, but they found that some of their constants varied little from element to element. In that way they not only obtained the first term of a series, but the whole series throughout the entire length of the spectrum, and where observations had been made in the case of the different elements they could of course check their calculations by the actual observations so made, and see how the theory seemed to be justified as the work was extended. The first line in a series must be considered to be comparable to a fundamental note in music. It represents really the longest light wave in the same way that the fundamental note in music represents the longest sound wave. Both series of results, obtained in the way I have described by Kayser and Runge and by Rydberg, show us that, in many cases, we may be almost certain to obtain from the higgledy-piggledy arrangement of the lines in the spectrum of any one substance two or three beautiful regular series like those that I have already shown you in the case of helium and asterium. There is a little difference in the nomenclature employed by the investigators to whom I have referred, as shown in the annexed table.

Series Nomenclature.

Intensity.	Kayser and Runge.	Rydberg.
Strongest	Principal series	Principal series
Weaker	1st subordinate series	Nebulous series
Weakest	2nd subordinate series	Sharp series

The strongest lines which they observed at the temperatures they worked with, they put into what they call a "principal series," and then the weaker lines were distributed among other two series. Kayser and Runge called them the "first-" and "second-subordinate" series; Rydberg calls them the "nebulous-series" and the "sharp-series." It is important to remember this in case you come across any reference to these matters, in order that you may see what the exact equivalent is. The lines of the principal series almost always reverse themselves very easily indeed—that is to say, that the absorption is indicated by them more readily than it is by the other lines. Then, when we come to the second subordinate or sharp series, it is found that these sometimes broaden out towards the red end of the spectrum.

This work, of course, has required considerable investigation; the first attempts were not quite satisfactory, because the observations on which it was based had not been of sufficient accuracy. With greater dispersion it has been found that some of the lines which were supposed at first to be single are really double; so that it is quite usual now when we consider this question of series to suppose that in some cases the series are composed of single lines, in other cases of doubles, and in other cases of triplets; and it was at first, indeed, imagined that in these differences we were face to face with a very important physical difference between the various elements, but Rydberg has suggested that possibly after all it may be a difference merely in the seeing.

He says: [1]

"The difference between the doubles and triplets is only relative. This opinion is confirmed by the fact that the triplets appear often in the form of doubles, the most refrangible component not having sufficient intensity to become visible. Further, the relative intensity of the components of the doubles seems equal to that of the two less refrangible components of the triplets.

"For these reasons I have dared to propose the hypothesis that the two kinds of component rays are of the same order, or that the doubles are only triplets of which the most refrangible component is too feeble to be seen, or has perhaps the absolute value of zero. . . ."

If the lines are more difficult to see, and if the sub-series of lines get stronger towards either the red end or the blue end, then we are more likely to see one line than two, and more likely to see two lines than three.

I have already referred to the many years old suggestion that a line is a remnant of a fluting. If you could see the whole fluting, you would see what is represented in the upper horizon of the diagram; if you

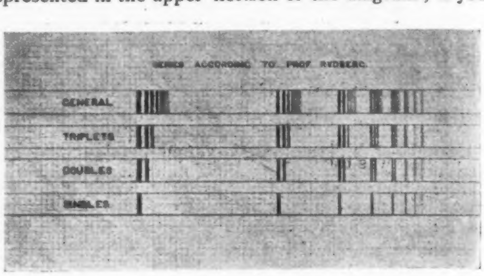


FIG. 5.—Diagram illustrating Rydberg's idea of the appearance of triplets, doubles, &c.

could not see the whole of it, you would get what is represented in the second horizon, that is to say, a triplet. If the third line were very difficult of observation you would only see a doublet, and if the inside line were weaker than the other you would only see a single line.

Single lines		Doubles		Triplets	
Principal series	Subordinate series	Principal series	Subordinate series	Principal series	Subordinate series
Helium			Helium	Oxygen	Oxygen
Asterium	Asterium	Hydrogen (?)	Hydrogen	Sulphur	Sulphur
		Lithium (?)	Lithium (?)	Selenium	Selenium
		Sodium	Sodium		Magnesium
		Potassium	Potassium		Calcium
		Rubidium			Strontium
		Cobalt			Zinc
			Copper		Cadmium
			Silver		Mercury
			Aluminium		
			Indium		
			Thallium		

There is only a very small number of the chemical elements which give us single lines; in the principal series, so far, we only know of helium and asterium: in the subordinate series we only know of asterium. The number of doubles, you will observe, is very much greater, but it is not so great in relation to the principal series as it is in the case of the subordinate series; but although we have nine elements giving us triplets in the subordinate series, we have only three which give them in the principal series.

(*To be continued.*)

THE DOVER MEETING OF THE BRITISH ASSOCIATION.

THE final arrangements for this year's meeting are now sufficiently completed for a fairly accurate forecast to be made. Whether the meeting will be large or small it is still too early to judge, but whether large or small it will certainly be a very interesting one. As to accommodation in the town, there is little doubt but that at the time of meeting ample accommodation will be available, though the committee have had great difficulties in inducing hotel keepers and lodging-house owners to

[1] *Kon. Sv. Vet. Ak. Hand.*, vol. 23, ii. p. 135.

reserve rooms for members of the Association, and have only partially succeeded. Dover being a sea-side resort, there has been a natural dislike on the part of owners of hotels and lodgings to offer to disturb those visitors who may possibly have come for a longer stay for the sake of members of the Association who may only wish to spend a week or so. There will, however, be accommodation available in Deal, Canterbury and Folkestone for those who cannot find rooms in Dover. It will be well, however, that intending visitors to the Dover Meeting should inform the local secretaries (E. Wollaston Knocker, C.B., and W. H. Pendlebury, M.A., Castle Hill House, Dover) of their intention, so that approximately the amount of extra accommodation may be known.

It has been usually the case that the secretaries of the various sections are accommodated at the same hotel to facilitate sectional arrangements. This year the Hospitality Committee has been able to arrange with the Head Masters and House Masters of Dover College to entertain the secretaries in the various boarding houses. Unfortunately, the accommodation is limited to the rooms usually occupied by the boys (each of whom has a separate bedroom to himself), so that it is impossible to take in secretaries accompanied by their wives. There will be a few other guests entertained by the Local Committee under the same conditions. The Masters of the various houses will act as hosts on behalf of the Hospitality Committee, and will look after the comfort of their guests. The College Masters will also give the first of the larger garden parties on Thursday, September 14. The Rev. J. N. Bacon has kindly undertaken to make a balloon ascent with objects simiiar to those which induced him to make an ascent at the Clifton College garden party. The situation of Dover with regard to the sea will doubtless add to the interest of such an ascent.

Lord Northbourne and Lord George Hamilton have kindly consented to allow members of the Association to inspect Betteshanger Park and Deal Castle respectively.

Owing to the fact that two of the days usually given up to excursions are required for the visit of the French Association to Dover and the return visit of the British Association to Boulogne, the number of excursions arranged for will be smaller than usual. The geologists and anthropologists have arranged a number of smaller excursions for the afternoons as usual, and these will, of course, not be interfered with. On the last day of the meeting (Wednesday) the Association is invited by the Dean and Chapter and Mayor and Corporation of Canterbury to pay a visit to that city to meet 200 members of the French Association, who will have previously been entertained to luncheon there. The Mayor and Corporation will entertain the British Association to tea. On the following day (Thursday) an excursion has been arranged to Rochester and Chatham Dockyard for those who do not care to go over to Boulogne. An opportunity will be given to visit the Agricultural College at Wye, near Ashford, which has been so successfully started by the County Councils of Kent and Surrey. The Principal, Mr. A. D. Hall, has invited members of the Association to pay the College a visit and inspect the experimental stations. It may be well to recall the fact that Wye College is especially included in the new University of London, though considerably outside the limit. For those members of the Association who visit Boulogne a most interesting programme has been arranged on the lines laid down in a former article (p. 181). The luncheon will be given by the civic authorities. The French Government has taken a great amount of interest in the gathering, and it is very likely that some prominent French statesman will attend to welcome the British Association in the name of the Government. In such case it is very likely that a similar compliment will be paid to the French Association on their visit to Dover. The French Government has also given instructions to the various Mayors and Prefects of the districts, through which the British Association will pass, in the five days' excursion at the conclusion of the meeting, to take official notice of the tour. The motor-car exhibition arranged by the Mayor of Dover for the Tuesday afternoon has been declared by the Board of Trade an international exhibition, so that no patents will be invalidated by premature disclosure at the Dover show. The French Association intends to give a considerable amount of attention to the automobile.

The Mayor of Dover will give a conversazione in the Town Hall and a garden party in the Connaught Park in addition to the reception at the motor-car exhibition.

The programme of local arrangements will be completed in a few days, and it will then be possible to make a fuller statement of the entertainments prepared for those members of the British Association who may visit Dover.

W. H. PENDLEBURY.

"*THE WEST INDIAN BULLETIN.*"

IT was on August 2 of last year that Mr. Chamberlain announced in the House of Commons the decision of the Government, based on the recommendations of the West India Royal Commissioners, to create a special Department of Agriculture for the distressed Colonies, to be presided over by Dr. Morris, of Kew Gardens, who had acted as scientific adviser to the Commissioners. Immediately the proposals were sanctioned by Parliament, active steps were taken to vigorously carry out the scheme. By the middle of September Dr. Morris had left for Barbados, which had been selected as the headquarters of the new establishment, and tours were at once undertaken to ascertain the requirements of the several islands. The result was the organising of a conference of the authorities on agricultural matters in the West Indian Colonies, each island sending delegates to attend the meetings, which were held, under the presidency of Dr. Morris at Barbados, in January last. On the first anniversary of the day on which the Colonial Secretary publicly set the scheme in motion there arrived in this country the first number of the *West Indian Bulletin*, the journal of the Imperial Agricultural Department for the West Indies, a publication which it is intended to supply gratis to all residents in the islands who ask for it. Its prototype is, naturally, the *Kew Bulletin*, but apparently it will not be issued at regular monthly intervals, only as occasion may require. The first part is a double number of 141 pages, devoted almost wholly to the proceedings at the agricultural conference of January already referred to, the subejcts dealt with being primarily of interest to the Colonists. In addition to the presidential address, dealing generally with the objects of the new Department, there were papers by Prof. d'Albuquerque on "Sugar-cane manurial experiments," and "The teaching of agricultural science at colleges"; by Mr. Bovell on the "Field treatment of the diseases of the sugar-cane," and the "Cost of growing sugar-canes in Barbados"; by Mr. Fawcett on "Agricultural instruction in agricultural schools in Jamaica," "Practical field instruction in Jamaica," and "The prevention of the introduction and spread of fungoid and insect pests in the West Indies"; by Mr. Francis Watts on "Central factories," Mr. William Douglas also dealing with the same subject. The Rev. William Simms discussed "Agricultural education"; Dr. Alford Nicholls, C.M.G., "Suggestions for agricultural development in the Leeward Islands"; Mr. Hart, "Improvement in agricultural methods in the West Indies"; and Prof. Carmody made "Brief suggestions on Colonial industries." The bare recital of the titles of the papers will show what a wide field of investigation and action was opened out, and it behoves all who are interested in the future welfare of

these unfortunate Colonies to secure this first number of the *West Indian Bulletin*, carefully study the array of facts contained therein, and see whether it is not possible to do more for reviving the ancient glories of the islands by personal energy, and the adaptation of modern methods of culture and preparation for the markets of the world, than by any possible benefits that can accrue from abolishing the sugar bounties by France and other countries, or the imposition by us of countervailing duties in favour of our own Colonies. While it is extremely doubtful whether the removal of the bounties would benefit the West Indian sugar planters to any appreciable extent, it seems almost absolutely certain that if they resolutely determined on keeping abreast of the times in management, machinery, selection of plants, &c., instead of being content with what was thought good enough by their fathers and grandfathers before beet-sugar entered into the competition, they would soon see an end to the worst features of that perpetual millstone —the depression in the West Indian sugar industry. As Dr. Morris said in his opening address, "The sugar industry in the smaller islands will never be in a satisfactory condition so long as the processes of crushing the canes and manufacturing the sugar remain as at present." H.

SIR EDWARD FRANKLAND, K.C.B., F.R.S.

NEWS of the death of Sir Edward Frankland will come as a surprise as well as a shock to all his friends, and will be received by the whole scientific world with feelings of the deepest regret.

The end came on Wednesday, August 9, in Norway, where Sir Edward had been in the habit of spending his summer holidays for many years. Born at Churchtown, near Lancaster, on January 18, 1825, he had entered upon his seventy-fifth year, but his upright, spare and active figure until quite recently gave the impression of a much younger man. It was noticeable, however, that he had aged in appearance perceptibly after the death of Lady Frankland (his second wife), which occurred rather suddenly in the spring of the present year.

Frankland received his early education at the Lancaster Grammar School, and subsequently became one of the first science masters at Queenwood College. From Queenwood he proceeded to Germany, and studied chemistry at Marburg and at Giessen. Returning to England he was appointed in 1851 first professor of chemistry at Owens College, Manchester, and there he remained for about seven years till his removal to London in 1857 to take charge of the chemical department in St. Bartholomew's Hospital Medical School. In 1863 he was appointed Fullerian Professor of Chemistry in the Royal Institution, and in 1865 he succeeded Hofmann at the College of Chemistry. The latter chair, which was soon afterwards transferred to the united School of Science and Royal School of Mines at South Kensington, he held till his retirement in 1885. Frankland was for many years a regular attendant at the meetings of the Chemical Society, and was president in 1871–72. His scientific work was rewarded also by honours from many foreign universities and academies, including the Institute of France, of which he was a corresponding member. For the last five years he held the office of Foreign Secretary of the Royal Society, and in 1894 he received the Copley Medal.

Sir Edward received the honour of knighthood in 1897, on the occasion of Her Majesty's Jubilee; but this, strange to say, was conferred, not in recognition of his very eminent services to chemical science, but in his more ordinary professional capacity as water analyst to the Home Department, having been for more than thirty years responsible for the annual reports to the Local Government Board on the quality of the metropolitan water supply.

Frankland's title to fame rests securely upon his important experimental investigations in pure chemistry accomplished chiefly within the twenty years from 1848 to 1868, and upon the impetus which was given to theoretical chemistry by the promulgation of his views concerning the combining capacity, or valency as it is now called, of the elements, which he derived from the results of his experimental work. In the years following 1840 the views of Liebig and of Dumas as to the nature of the carbon compounds, usually spoken of as organic, attracted the attention of the whole chemical world, and efforts were especially directed to the problem of how to isolate the compound radicals which they were supposed to contain in the form of oxide, hydrate, chloride, bromide, iodide and so forth. The radical of common alcohol was naturally one to receive early attention, and to this subject Frankland devoted his earliest efforts. He was successful in 1848 in isolating a substance to which he and all the chemists of that day gave the name *ethyl*, in the belief that it was really the radical of which common alcohol was the hydrate and common ether the oxide, and which was present as the characteristic basis of all the numerous compound ethers or ethereal salts then known. Though in strictness an error, long since corrected by applying the law of Avogadro, was involved in this assumption, the experimental method employed led to the further discovery of the remarkable series of compounds known as organo-metallic, and to the subsequent recognition of the varying power possessed by the metals and metalloids of uniting with alcohol radicals, with the halogens and with oxygen. The recognition of this diversity of combining capacity, and of the fact that each elementary atom possesses a maximum capacity beyond which its power of chemical union is incapable of extending, supplied the basis of the modern doctrine of valency and of all the consequences which follow from the idea of the orderly linking of atoms, afterwards developed by Kekulé into the theory of structure, upon which the whole system of organic chemistry is at the present day established.

At a later period Frankland pursued investigations in the then new and always difficult department of synthetical chemistry. In this he was associated for a time with Mr. B. F. Duppa.

Among others of his researches must be mentioned his experiments on the influence of pressure upon the luminosity of flame. These resulted in a theory of luminosity which for many years divided the favour of chemists and physicists with the older theory of Davy, according to which the luminosity of hydrocarbon flames, at least, is attributed to the presence in the flame of incandescent solid particles. Frankland's theory pointed to the effect of density in the ignited vaporous constituents of luminous flames.

Reference must also be made to the protracted and laborious study of gas and, especially, water supplies, which occupied so many of the later years of his life. Having been appointed a member of the Royal Commission on the Pollution of Rivers and Domestic Water Supply in 1863, he continued henceforward to give close attention to this important subject, and if his analytical methods and his conclusions were not universally adopted, he remained to the end of his life the most eminent authority on the chemical examination of water.

Sir Edward Frankland left several sons and daughters, among whom his eldest son, Dr. Percy Faraday Frankland, F.R.S., professor in the Mason University College, Birmingham, is distinguished as a scientific chemist.

The funeral will take place at Reigate on August 22.

THE NATIONAL PHYSICAL LABORATORY.

THE realisation of the scheme for the establishment of a National Physical Laboratory is primarily due to two addresses delivered before the British Association in 1891 and 1895 by Prof. Oliver Lodge and the late Sir Douglas Galton respectively. The fact that Sir Douglas Galton, when president of the Association, did all in his power to support the proposal originally made by Prof. Lodge, led to the matter being laid before the Prime Minister by a strong deputation. A committee, of which Lord Rayleigh was chairman, was then appointed by the Treasury, and after taking evidence, reported in favour of the establishment of a public institution for standardising and verifying instruments, for testing materials, and for the determination of physical constants. They further recommended that the institution should be established by extending the Kew Observatory in the Old Deer Park, Richmond, and that the Royal Society should be invited to control it and to nominate a governing body, on which commercial interests should be represented, the choice of the members of such body not being confined to Fellows of the Society.

These recommendations were approved, and to give effect to them the Government undertook to ask Parliament for 12,000*l*. for buildings and for 4000*l*. a year. A scheme for the management of the new institution has been approved by the Treasury, and the first instalment of the promised grants has been sanctioned by the Legislature. The Kew Observatory Committee are willing that the Institution which they have managed very successfully should be merged in the National Physical Laboratory, which will thus become possessed of an endowment of 458*l*. per annum from the Gassiot Trust, and of an income of about 2700*l*. from fees for standardising. These receipts have, in the past, rather more than covered the expenses of carrying on the work of the Observatory.

The ultimate control of the National Physical Laboratory is placed in the hands of the Royal Society, but the constitution of the bodies which manage it directly can only be altered with the consent of the Treasury. These are an Executive Committee and a General Board. The latter is a relatively large body, to which the Executive Committee must report annually, and to which it must submit its scheme of work for the next year. An essential feature in the constitution of the General Board is that twelve of its members are nominated by six of the great technical societies—viz. the Institutions of Civil, Mechanical, Electrical and Naval Engineers, the Iron and Steel Institute, and the Society of Chemical Industry. Six of these representatives of "commercial interests" are also to be members of the Executive Committee, which will ultimately consist of twelve ordinary and five official members, of whom the latter are: the President of the Royal Society, the Chairman of the Committee, the Permanent Secretary of the Board of Trade, and the Treasurer and one of the Secretaries of the Royal Society. In the first instance, six members of the existing Kew Observatory Committee will also have seats on the Executive Committee, but their places will not be filled up when their period of office expires. Finally, it is in the power of the Executive Committee to appoint sub-committees to superintend particular departments or investigations. The members of these sub-committees need not necessarily be members either of the General Board or of the Executive Committee.

Preliminary arrangements have been in progress for some time in order that the National Physical Laboratory should be organised as soon as possible after the requisite funds were voted by Parliament.

The six technical societies have nominated their representatives, the General Board and Executive Committee have been constituted, and general satisfaction will be felt at the announcement that Lord Rayleigh has accepted the chairmanship of these bodies.

On the recommendation of the Executive Committee, the Council of the Royal Society has appointed Mr. R. T. Glazebrook, F.R.S., now Principal of University College, Liverpool, to the important post of Director of the National Physical Laboratory. A number of sub-committees have also been organised by the Executive Committee, which have been requested to make suggestions preparatory to the drawing up of a detailed scheme of work and of the plans of the new buildings.

The members of the Executive Committee are:—

Lord Lister, P.R.S., Lord Rayleigh (*Chairman*), Mr. A. B. Kempe, Treas. R.S., Prof. A. W. Rücker, Sec. R.S., and Sir Courtenay Boyle (*ex officio*), Captain W. de W. Abney, Sir N. Barnaby, Mr. G. Beilby, Sir E. H. Carbutt, Bart., Captain E. W. Creak, R.N., Prof. R. B. Clifton, Prof. G. C. Foster, Mr. F. Galton, Prof. O. J. Lodge, Sir A. Noble, Prof J. Perry, Sir W. Roberts-Austen, Prof. A. Schuster, Mr. A. Siemens, General Sir R. Strachey, Prof. J. J. Thomson, Dr. T. E. Thorpe, Sir J. Wolfe Barry.

In addition to the above, the following are also members of the General Board:—

Sir M. Foster, Sec. R.S. (*ex officio*), Sir F. A. Abel, Bart., Prof. W. G. Adams, Prof. W. E. Ayrton, Mr. H. Bell, Mr. A. Buchan, Mr. R. E. Crompton, Prof. G. F. Fitzgerald, Prof. J. Joly, Lord Kelvin, Mr. J. T. Milton, Sir W. H Preece, Mr. W. F. Reid, the Earl of Rosse, Dr. R. H. Scott, Mr. W. N. Shaw, Mr. C. E. Stromeyer, Admiral Sir W. Wharton, Sir W. H. White.

The following have also been requested to serve on one or other of the sub-committees above referred to:—

Messrs. E. D. Archibald, C. V. Boys, Prof. H. L. Callendar, Messrs. Forbes Carpenter, W. H. M. Christie, J. H. Dallmeyer, Prof. J. A. Ewing, Mr. S. Z. de Ferrant Prof. J. A. Fleming, Messrs. R. E. Froude, E. H. Griffiths, J. Mansergh, T. Matthews, W. H. Maw, Dr. L. Mond, Hon. C. A. Parsons, Prof. A. W. Reinold, Captain H. R. Sankey, Messrs. J. Swinburne, G. J. Symons, H. A. Taylor, Prof. S. P. Thompson, Messrs. J. I. Thornycroft, C. H. Wordingham and A. F. Yarrow.

It will thus be seen that the National Physical Laboratory is being founded on a wide basis. A definite scheme of work will be arranged during the autumn. The Director will, it is hoped, take up the duties of his office on January 1, 1900, and the planning and erection of the new buildings will then proceed with as little delay as possible.

NOTES.

WE regret to learn that Prof. Bunsen, the veteran chemist, is lying seriously ill at his residence in Heidelberg, and that little hope is entertained of his recovery.

M. DE FONVIELLE, writing from Paris, says: "M. Janssen has left Paris for his usual annual journey to the Observatory on the summit of Mont Blanc, to inspect the instruments installed there.—The Minister of Finance granted to MM. Hermite, at Besançon, the sum of fifty pounds for their experiments with free balloons. It is intended to send up a balloon with new recording apparatus during the forthcoming meeting of the French Association at Boulogne."

MR. BALFOUR has consented to take the chair at a festival dinner at the end of November in aid of the fund now being raised to provide new laboratories at King's College, London.

THE autumn meeting of the Iron and Steel Institute was opened at Manchester on Tuesday, under the presidency of Sir William Roberts-Austen, K.C.B., F.R.S.

THE Superintendent of the U.S. Coast and Geodetic Survey has designated Dr. Frank Schlesinger, Columbia University, New York City, to take charge of the variation of latitude observations at Ukiah, California, in accordance with the plans of the International Geodetic Association.

IT is with great regret that we learn of the death of Dr. Daniel G. Brinton, the distinguished and erudite American anthropologist, in his sixty-third year. Although Dr. Brinton was for many years Professor of American Archæology and Linguistics in the University of Pennsylvania, we understand that he had very little actual teaching to do, and thus was at liberty to devote himself to research. Dr. Brinton was known as an enthusiastic student of linguistics, and had a profound knowledge of American languages. He had recently bequeathed his extensive and very valuable linguistic library to his University The following are some of his contributions to anthropological science: "The Floridean Peninsula: its Indian Tribes and Antiquities"; "The Myths of the New World" (third edition, 1896); "The Religious Sentiment: a Contribution to the Science of Religion"; "American Hero Myths"; "The Chronicles of the Mayas"; "The Annals of the Cakchiquels"; "Ancient Nahuatl Poetry"; "Races and Peoples"; "Lectures on Ethnography"; "Essays of an Americanist"; "The American Race"; "The Pursuit of Happiness"; "Nagualism"; "Grammar of the Choctaw Language"; "Grammar of the Cakchiquel Language," and various other papers and memoirs.

A HURRICANE of unusual severity struck the island of Montserrat, West Indies, on the 7th inst., and caused great devastation there and at other points of its path. It is reported to have reached Porto Rico on the 8th, to have been central over the north-east of Cuba on the 10th, and to have reached the southern part of Florida on the 12th. As pointed out in our note of July 20 last (p. 281), West India hurricanes are most prevalent at this season of the year; the average number between August and November is two a month, but the tracks are often over the open sea, and do not come in contact with the numerous islands. The course taken by the storm in question was more to the northward of the hurricane which caused so much damage at Barbados and St. Vincent last September, and has taken a somewhat more westerly route than the average path. The rate at which it travelled seems to have been under ten miles an hour, which is about the usual velocity in those latitudes; but this has no relation to the force of wind in the whirl of the storm, which probably reached a rate of 100 miles an hour at times. By a telegram from New York on the 12th, the fury of the storm appeared to have abated, probably owing to contact with the land; but for further particulars as to its behaviour, we must wait for the official reports of the Governors of the various islands and of the United States authorities.

PROF. E. VAN AUBEL, assistant professor of physics in the University of Ghent, sends us an interesting note with reference to Dr. C. G. Knott's recent experiments on magnetic strain in bismuth (p. 192) and Mr. Shelford Bidwell's comment upon them (p. 222). It appears that, in 1892, Prof. van Aubel prepared a paper on the same subject, entitled "Influence de l'aimantation sur la longueur d'un barreau de bismuth," and it was published in the *Journal de physique théorique et appliquée* (troisième serie, tome i. p. 424, 1892). His experiments were made with perfectly pure bismuth, prepared by electrolysis, and used by Prof. A. Classen for the determination of the atomic weight of the metal. An interference method was employed to determine any change of length, but no change was found. Prof. van Aubel expresses his satisfaction that the results of his investigation have now been confirmed by Mr. Shelford Bidwell's new experiments.

THE value of towing experiments upon small-scale models of ships for the purpose of deducing the resistance of a full-sized ship from that of the model was first demonstrated by the late Mr. William Froude, whose son, Mr. R. E. Froude, F.R.S., is the superintendent of experiments of this kind at the Admiralty Experimental Works, Gosport. The Construction Bureau of the United States Navy Department has appreciated for many years the value of an experimental basin, but it was unable to secure a grant for the purpose until about two years ago, when Congress granted 100,000 dols. for this work. The basin proper was finished towards the close of last year, and the special machinery and apparatus have now just been completed and installed, after a good deal of delay, due indirectly to the war with Spain. The basin is situated in the Washington Navy Yard, but the building is 500 feet long and about 50 feet wide inside. The water surface of the basin is slightly shorter than the building, being about 470 feet long. The deep portion is about 370 feet long, the south end, from which runs begin, being shallow. The water surface is 43 feet wide, and the depth from top of coping to the bottom of the basin is 14 feet 8 inches. The basin is thus larger than any other in existence, and it is well equipped with machinery for the performance of experiments. Electricity is used to drive the overhead carriage which tows the models; in fact, it is used for all mechanical work in connection with the model tank. Experiments are now being made to determine frictional coefficients of varnished surfaces and other constants needed in the use of the basin. Experiments are also being made as opportunity serves upon models of the naval vessels already built and tried for the purpose of accumulating data which will be constantly needed during the life of the tank.

AN important paper has been recently communicated to the Swedish Academy of Sciences by Dr. Hildebrandsson, Director of Upsala Observatory, entitled "Researches on the centres of action of the atmosphere: II. Rainfall." In a previous paper, published in 1897, it was shown that an intimate relation exists between the variations of barometric pressure in different regions of the earth, *e.g.* if the pressure of the air is above or below the mean at the Azores, the reverse condition would obtain between Iceland and Scotland; and similarly for other parts of the world. Rainfall is perhaps the most important element in the economy of nations, but it is apparently the most variable and irregular of all when dealt with for short periods, but for seasons, or longer periods, considerable regularity is observed. The paper contains tables and curves showing seasonal and yearly values of rainfall for a number of places; and from these it is seen, for instance, that as regards Iceland and the Azores the variations in the rainfall during the cold season are almost always in the opposite direction, and equally clear results are shown to exist for other localities. It is evident that a prediction of rainfall six months in advance would be of great utility in India. With regard to those regions, the author finds that the amount of rainfall between October and March in Siberia is generally in inverse proportion to the amount which will fall in India during the following rainy season. It is not pretended that any definite laws have been determined, but the provisional results seem to be of sufficient importance to warrant a more detailed inquiry.

MR. W. E. HOYLE, Director of the Manchester Museum, Owens College, has presented a very satisfactory report upon the progress made during 1898. The museum is not merely a popular resort, but also an institution which works in many

ways for the advancement of science. The most important gift to the museum during last year was a collection of birds which formed the basis of Mr. H. E. Dresser's work on "The Birds of Europe," and his monographs of the Rollers and of the Bee-eaters. Neither trouble nor expense was spared to make the collection as complete as possible, and more particularly to make it a working collection. As regards the extent of the collection, there are of Bee-eaters about 30 species and 155 specimens, and of Rollers 26 species with 112 specimens; whilst the Western Palæarctic collection contains 721 and the Eastern 260, making a total of 1037 species, or more, according to the British Museum Catalogue. In almost every instance these forms are represented not merely by a single skin but by several, showing the differences of plumage due to sex, age, and local variation, the collection amounting in total to some 10,000 specimens. There are several types and numerous rarities, among which may be mentioned two specimens of the Rosy Gull, whose nesting-place was discovered by Nansen in Franz Josef Land, and two Labrador Falcons. Mr. Hoyle rightly points out that the acquisition of this valuable collection is a piece of singular good fortune for the Manchester Museum, and therefore for all students of ornithology in the neighbourhood.

SOME interesting experiments on the corrosion of metals by sea water have (says *Engineering*) been carried out at Kiel during the past two years. The plan followed was to cut off twelve specimens of the metal to be tested, of which three were kept as "witnesses," whilst the other nine were placed in salt water. At the end of eight months three of the latter were withdrawn and compared with the "witnesses." Eight months later a second set were withdrawn and a fresh comparison made, those then left being taken out after the lapse of a third period of eight months. The metals tested included alloys of copper rich in zinc, bronzes containing little zinc, bronzes containing no zinc, pure aluminium bronzes, and finally bronzes containing aluminium and zinc or zinc and iron. The latter in particular showed remarkable resistance to the corrosive powers of sea water, being practically untouched at the end of a two years' immersion. The alloys containing zinc, however, gave much less favourable results. The copper-tin alloys and copper-aluminium alloys and the iron bronzes resisted perfectly when immersed in sea water in contact with iron. The bronzes containing iron, when placed in contact with those of tin, showed a loss by corrosion. It is thus important, if corrosion is to be prevented, to avoid placing these alloys in contact with metals electro-positive to them.

AN account of the application of liquefied carbonic acid gas to extinguish underground fires was given by Mr. George Spencer at the recent meeting of the Institution of Mining Engineers. At a colliery with which Mr. Spencer was connected a fire occurred in a heading, as the result of a fall of roof and sides on steam-pipes. The heading was built off with as little delay as possible, but notwithstanding all efforts to shut out the air, sufficient reached the seat of fire to keep it burning slowly. It was therefore decided to apply carbon dioxide, and for this purpose six cylinders of liquefied gas were successfully used. It is not claimed that the method described can be successfully applied to all gob-fires, but there are undoubtedly many cases which might be so treated. In case of fire on shipboard the use of carbon dioxide would no doubt prove invaluable, as it could be quickly applied, and would not cause the same damage to cargoes as water.

THE numbers of the *Kew Bulletin* just issued (Nos. 144–146) contain several articles and items of information which serve to show the influence which Kew exerts on botanical science and plant industries in many parts of the world. The life-history of a parasitic fungus which for the past two years has destroyed a considerable number of examples of the beautiful flowering shrub *Prunus japonica*, Thumb., growing in Kew Gardens, is described by Mr. G. Massee, and preventive measures of dealing with it are given. An account is given of experiments made in Queensland for the improvement of the sugar-cane by chemical selection upon a method proposed by Sir William Thiselton-Dyer. The object of the experiments was to ascertain the possibility of increasing the average richness and purity of the juice of a given variety of sugar-cane, by chemical analysis of the juice from each of the "seed canes"—that is, canes from which the plants were to be taken—and by the selection of those plants from the seed canes which were found by the analysis to yield the richest and purest juice. The results of the experiments show clearly that canes planted from rich seed canes selected in this way yielded a juice of higher sucrose content and lower glucose content than canes planted from those shown chemically to be of a "low" grade.

THREE new analyses of moldavite glass are published by Dr. C. v. John in the *Verhandlungen der k.k. geolog. Reichsanstalt*, Nos. 6 and 7, 1899. The specimens were handed over by Dr. F. E. Suess for investigation, and with them a specimen of glass from Netin in Moravia, received from Prof. Dvorský, of Brünn. This glass fragment, considered by Drs. Dvorský and Suess to be of artificial origin, was analysed in order that its chemical composition might be compared with that of true moldavite. Similar fragments of artificial glass have been frequently mistaken for moldavite, but differ from the latter in the absence of the characteristic surface sculpture, as also by the different shade of colour. The three specimens of moldavite showed a strikingly similar chemical composition, in which the potash was considerably in excess of the soda. The glass fragment from Netin showed a very different composition, and proved to be a potash glass in which the percentage of potash was abnormally high. The percentage of silica, potash, and soda in moldavite from Budweis was 82·62, 2·28, and 0·63 respectively, while the artificial glass yielded silica 52·32, potash 22·84, and soda 0·24 per cent. The author appends a table containing all the analyses of moldavite known to him, and draws attention to the similarity of composition shown. He remarks that the iron occurs for the most part as ferrous oxide, and that ferric iron is found in larger quantities only in those varieties having a strong brown colour. The belief is expressed that in moldavite the potash is always in excess of the soda, and the author states that in all cases the sum of the alkalis contained is found to be very similar.

IN the same number of the *Verhandlungen* is published a paper by A. Rosiwal, in which some additional results of his technical investigation of building-stones are described. In this paper the author clearly explains his new method whereby the relative "freshness" and "degree of weathering" of various building-stones may be expressed in figures. This ingenious method consists in the application of simple formulæ, and it is clearly illustrated by numerous examples.

DR. DAVISON's report on the Hereford earthquake of 1896 contains a brief note, by Mr. E. Greenly, on the relation between the intensity of the shock and the geological structure of the Bangor-Anglesey district. In a paper recently published in the *Transactions* of the Edinburgh Geological Society, Mr. Greenly gives the evidence at greater length. He shows that the shock was felt most powerfully in houses standing upon Carboniferous and Ordovician rocks, less so in those upon the hard volcanic series of Bangor, and least of all in the Schistose Complex of Anglesey; the general result being that "the shock

was felt inversely to the degree of elasticity of the rocks." It was, moreover, stronger in the neighbourhood of large boundary faults, where effects due to reflexion would tend to be well-marked. Mr. Greenly also makes the interesting suggestion that, in their passage to the Bangor-Anglesey district, the earth-waves must be influenced by their having to traverse the older palæozoic rocks of the Snowdonian synclinal fold.

DESPITE the important influence of modern theories of oscillatory discharges on our knowledge of the phenomena of lightning, but few attempts seem to have been made to present in a readable and concise form recently observed facts, both theoretical and experimental, bearing on the important question of lightning protection. The Weather Bureau of the United States Department of Agriculture has done good service in publishing, in the form of an illustrated pamphlet of seventy-four pages, a bulletin on "Lightning and the Electricity of the Air," prepared under the direction of Mr. Willis L. Moore. The first part, by Mr. Alexander G. McAdie, is occupied chiefly with theoretical considerations, and includes descriptions of various forms of kites used for modern repetitions of Franklin's experiment, investigations of the potential of the air made on the Washington Monument and elsewhere, notes on auroral displays, photographs of lightning flashes, and a full summary of the best forms of lightning conductors, of general directions for the erection of rods, of precautions to be observed in thunderstorms, and of the treatment of patients struck by lightning. A brief account of the principles of lightning arresters and the use of choke coils for alternating current-circuits concludes this part.

PART II. of the bulletin referred to above, by Mr. Alfred J. Henry, deals with statistics of loss of life and property by lightning, both in the United States and in Europe. It calls attention to the danger to live stock caused by wire fences, the effects of the soil, the kind of trees usually struck (under which head the susceptibility of oaks is prominently shown) and the question as to whether the danger of lightning stroke is increasing or decreasing. In the last question a distinction is made between "cold" strokes and those which cause fire, and it would appear that in Bavaria the total number of strokes is on the increase, but the percentage of fire-causing strokes is on the decrease. This section is illustrated by photographs showing the effects of lightning on different trees, and a map showing the relative frequency of thunderstorms in different parts of the United States.

WE have recently received from Messrs. Williams and Norgate the annual number of *Mittheilungen der Naturforschenden Gesellschaft in Bern* for 1897. In it M. L. Crelier contributes a paper on the Bessel's function of the second kind $S_n(x)$, in which are deduced a number of formulæ involving Bessel's functions, which the author claims to be new. An account of the exhumation of the late Jacob Steiner is also given, accompanied by measurements of the great mathematician's skull.

PROF. AUGUSTO RIGHI contributes to the *Rendiconti* of the Bologna Academy a paper on the absorption of light on the part of a gas placed in a magnetic field. This forms a continuation of Prof. Righi's investigations on the Zeeman effect. The new experiments, conducted with the aid of a large Rowland's grating, deal chiefly with the inverse of Zeeman's phenomena, both with hypoazotid and with polarised light in sodium vapour. The investigation has an important bearing on results previously obtained by Macaluso and Corbino.

M. E. H. AMAGAT, writing in the *Journal de Physique* for July, proposes a new form of the relation $f(p, v, T)=0$ for fluids. From considerations, partly theoretical and partly experimental, M. Amagat is led to adopt the formula

$$\left\{p+\frac{v-[a+m(v-b)+c/(v-b)]T}{kv^r-\alpha+n\sqrt{[(v-\beta)^2+d^2]}}\right\}v=RT,$$

a formula which, in the case of carbonic acid, agrees closely with observations of the pressures corresponding to given volumes and temperatures, both in the gaseous state and along the curve of saturation.

A NEW classification of the Tineæ of Central Europe is given by Dr. Arnold Spuler in the *Sitzungsberichte der physikalisch-medicinischen Societät* (Erlangen) for 1898. Dr. Spuler follows modern views in placing the large Cossidæ among the Tineæ next before the family Tortricoidæ.

WE have just received two new parts of the *Bulletin* of the New York State Museum (vol. vi. Nos. 26 and 27, April and May 1899). Both are by Dr. Ephraim Porter Felt, State Entomologist. The first relates to the collection, preservation, and distribution of New York insects, and contains illustrations of apparatus. The second concerns shade-tree pests, and relates to various Coleoptera, Lepidoptera, Hymenoptera, and Hemiptera. It is illustrated, though it is but a small pamphlet, with five admirable plates, besides figures in the text.

THE volume containing the numbers of the *Bulletin of Miscellaneous Information* issued by the Royal Gardens, Kew, during 1898, has just been published. Many of the articles in this most serviceable publication have already been referred to in these columns, and we need now only call attention to the issue of them in a form convenient for reference. Particular attention is given in the volume to the cultivation of rubber plants, artificial indigo, China grass, and other subjects of economic importance.

THE seventh Robert Boyle Lecture on the "Physiological Perception of Musical Tone," delivered before the Oxford University Scientific Club on June 6, by Prof. J. G. McKendrick, F.R.S., has been published in pamphlet form by Mr. Henry Frowde. An abstract of the lecture appeared in NATURE of June 15.

THE publication of a series of "Studien und Skizzen aus Naturwissenschaft und Philosophie," by Dr. Adolf Wagner, has been commenced by the firm of the Gebrüder Borntraeger, Berlin. The first volume is an essay "Über wissenschaftliches Denken und über populäre Wissenschaft," which should be read by persons who instruct the scientific laity by spoken or written words; and the second volume is concerned with the "Problem der Willensfreiheit." A number of other volumes are in preparation.

A DESCRIPTIVE catalogue of the Tunicata in the Australian Museum, Sydney, N.S.W., prepared by Prof. W. A. Herdman, F.R.S., has been published by order of the Trustees of the Museum. The collection upon which the catalogue is based was sent to Prof. Herdman several years ago, but certain circumstances prevented the publication of the work in 1893, when it was ready for press. The work is not put forward as a monograph on Australian Tunicata, so the only anatomical and histological details included are those required for the description of the various species. A list of the Tunicata Fauna of Australian seas, so far as it is at present known, is given, and also a brief general account of the structure and life-history of a typical Ascidian, which may be of service to students referring to the catalogue. Numerous plates illustrate the various species described.

THE additions to the Zoological Society's Gardens during the past week include a Pinche Monkey (*Midas aedipus*) from

Colombia, presented by Mr. R. E. Stone; two Common Duikers (*Cephalophus grimmi*), six Swainson's Francolins (*Pternistes swainsoni*) from South Africa, presented by Mr. J. E. Matcham; a Suricate (*Suricata tetradactyla*) from South Africa, a Common Hamster (Albino) (*Cricetus frumentarius*), European; an Antillean Boa (*Boa diviniloque*) from the West Indies, deposited; two Spotted Turtle Doves (*Turtur suratensis*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

HOLMES' COMET 1899 *d* (1892 III.).

Ephemeris for 12h. Greenwich Mean Time.

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br. r^{-2}	Br. $(r\Delta)^{-2}$
August 17	2 51 17·17	+36 29 53·4		
18	52 16·44	36 45 24·3		
19	53 14 43	37 0 51·8		
20	54 11·12	37 16 15·8	0·1905	0·04889
21	55 6·48	37 31 36·3		
22	56 0·47	37 46 53 2		
23	56 53·06	38 2 6·3		
24	2 57 44 22	+38 17 15·7	0·1888	0·04999

MOTION OF APSE LINE OF α GEMINORUM.—In a previous communication to the *Mem. Soc. Degli Spett. Ital.* (vol. xxvi., 1897), M. A. Belopolsky has drawn attention to the rapid motion of the line of apsides in the system of α Geminorum (Castor), and now, in the last issue of the same journal (vol. xxviii. pp. 103–108, 1899), he gives the results of more recent work on this interesting double star. The former measures were obtained from a series of spectrographs obtained at Pulkowa during one year, and were not sufficiently representative to give certain results. He has now at his disposal observations which he has made during the past three years, and in the present paper confines himself to the examination of three groups of these observations, reserving the discussion of the whole for a later article. These groups of observations embrace the periods: (1) 1896, March 8 to April 26; (2) 1898, March 15 to May 2; (3) 1899, January 19 to April 16. In the calculation several difficulties are found, the chief of which are the rapid movement (period 2·93 days), the uncertainty of a few thousandths of the period producing an error of several degrees in the true anomaly, and also the uncertainty of the time of passage through *Periastron*.

Tables are given showing comparisons between the calculated and observed values for the velocity in the line of sight, for all the dates in the three groups of observations, from which the author concludes that the probable error is only about ± 0·368 l.g. (± 0·92 miles). He finally concludes that the observed rapid movement of the line of apsides is real, and that the *period of this revolution* is

4 years 40 days = 2100 days.

He attributes the cause of this to the probable flattening of the components, and mentions that a flattening of one-seventh would be sufficient, if the dimensions of the system are equal to those of Algol, to produce the observed motion.

MR. TEBBUTT'S OBSERVATORY.—In presenting his report of the work done at his observatory at Windsor, New South Wales, during the year 1898, Mr. John Tebbutt states that the past year was remarkable for the large number of clear nights during the autumn, winter and spring months, rendering it possible to get a large amount of work done.

Meridian work was carried out with a 3-inch Cooke transit, the timekeeper being a Poole 8-day chronometer.

Extra-meridian work consisted of observations of occultations, planets, and comets. With the 8-inch equatorial thirty-six disappearances at the moon's dark limb were measured and the results published. The same instrument, in conjunction with the Grubb filar micrometer, was employed on fifty-seven nights in planetary observation; 73 comparisons of Vesta, 211 of Iris, 107 of Isis, 91 of Jupiter and η Virginis, 132 of Uranus and ω^1 Scorpii, and 132 of Uranus and ω^2 Scorpii, were recorded; and comparisons with the measures published by other observers have proved to be very satisfactory.

The observations of comets have been made with both the 4½-inch and 8-inch equatorials, and have included measures of Encke's Comet, and Comet Coddington-Pauly, the latter being followed from June 15 to March 3, 764 measures of the comet and 138 of comparison stars being made on 103 nights during that period.

Attempts to observe Comets Perrine, *e* and *h*, 1898, were unsuccessful owing to their proximity to the sun.

All the observations, computations and reductions have been made by the proprietor of the observatory, it being extremely difficult to obtain even occasional assistance.

TEMPERATURES IN GASEOUS NEBULÆ.—Mr. F. E. Nipher, in a paper read before the Academy of Science, St Louis (vol. ix., No. 4), discussed the conditions of temperature, &c., in a gravitating nebula having *uniform temperature* throughout its mass. In a second paper he now discusses the same subject on the different assumption that the initial temperature *diminishes* from the centre outwards. After a lengthy mathematical discussion he derives a general formula

$$T = T_0(1+n)\left(\frac{r_0}{r}\right)^{1-n}$$

which reduces to Ritter's equation if the temperature of the mass be assumed initially uniform. He concludes that in general the temperature throughout a nebula is to be given in terms of the coordinates of the point in space where the temperature is to be determined, and the *ratio of contraction* from any given initial condition. If the temperature remains constant throughout the mass, then Ritter's equation would hold during contraction. If on account of unequal permeability to heat the temperature should become unequal, the law of temperature change as a function of the ratio of contraction becomes more complex, so that if at any time the temperature varies inversely as the *n*th power of the distance from the centre, the ratio of temperature change at any contracting surface will be given by the above equation, in which it is evident, from physical conditions, that *n* cannot be less than zero.

THE RECENT PERSEID METEORIC SHOWER.

A SERIES of very clear nights enabled the Perseids to be well observed this year. The shower was not of unusual brilliancy, but it furnished a considerable number of meteors, and they appear to have been widely observed. The occurrence of the Perseid display now excites not only the attention of the meteoric enthusiast, but is seriously observed by astronomers generally, and the application of photography to work of this kind has greatly stimulated the interest in it.

On August 9 the writer watched the north-eastern sky between about 10h. 15m. and 13h., but a few clouds prevailed during the first hour. 38 meteors were seen, of which 26 were Perseids. On August 10, between about 10h. and 13h. 30m., 91 meteors were seen, of which 72 were Perseids. On August 11, between 10h and 13h. 30m., 90 meteors were observed, including 68 Perseids. On August 12, between 10h. and 13h. 30m., 62 meteors were counted, and amongst these were 43 Perseids. On August 13, 23 meteors (10 Perseids) were seen in 2 hours, and on August 14, 29 meteors (12 Perseids) were recorded in 2½ hours.

On August 10, between 11h. 10m. and 14h. 35m., Prof. A. S. Herschel at Slough observed 104 meteors, and after making allowance for time spent in registering the paths the horary number of meteors for one observer would be about 40. He describes the maximum as having been observed between 12h. and 12h. 30m., when several bright meteors succeeded each other at short intervals.

On August 10 Mr. T. H. Astbury, observing at Shifnal, Salop, says that thirty-four meteors were seen between 10h. and 11h., the great majority being Perseids. There was also an active radiant in Cygnus.

On August 11 only about eighteen meteors were seen from 10h. till 11h., so that he concluded the maximum occurred on the 10th, when the meteors were brighter and more numerous.

According to the Bristol observations already alluded to, very little decline in numbers was, however, noticed on August 11, and to exhibit this more readily, the following table has been compiled:—

Date.	Time of observation. h. h.	Actual length. hrs.	Meteors seen.	Perseids.	Radiant. α δ
Aug. 9	$10\frac{1}{4}$–$12\frac{3}{4}$	2	38	26	$44^\circ + 57^\circ$
10	10 –$13\frac{1}{2}$	3	91	72	44 + 57
11	10 –$13\frac{1}{2}$	3	90	68	46 + 57
12	10 –$13\frac{1}{2}$	3	62	43	48 + 57
13	10 –$12\frac{1}{2}$	2	23	10	49 + 58
14	10 –$12\frac{1}{2}$	$2\frac{1}{4}$	29	12	50 + 56

The meteors seen on the 10th were, however, rather brighter on the whole than those on the 11th. The largest meteors were as follows:—

No.	Date.	Time.	Mag.	Path. From	To
1	Aug. 9	11 4	♃	$15^\circ + 28^\circ$	$11^\circ + 21^\circ$
2		11 32	♃	$296\frac{1}{2} + 57$	$278 + 36\frac{1}{2}$
3		12 7	♀	239· + 60	235 + 37
4	Aug. 10	10 14	♀	293 + 60	271 + 38
5		10 54	♃	$23\frac{1}{2} + 38$	17 + 29
6		11 36	♃	$49\frac{1}{2} + 37\frac{1}{2}$	$50\frac{1}{2} + 32$
7		13 18	♃	50 + 67	58 + 73
8	Aug. 11	11 9	♃	$18\frac{1}{2} + 51$	$5 + 44\frac{1}{2}$
9	Aug. 12	10 16	♃	$5\frac{1}{2} + 6$	1 − 6
10		10 39	♃	$326 + 1\frac{1}{2}$	318 − 11
11		12 $1\frac{1}{2}$	♀	$4\frac{1}{2} + 43$	$347 + 27\frac{1}{2}$

No. 3 was also seen by Prof. Herschel, and No. 4 by Mr. Astbury. The majority of the remainder were seen by various other observers, and their real paths will be calculated.

On August 12 the shower had markedly declined, though it was tolerably active between 10h. and 11h. The position of the radiant point exhibited the usual diurnal motion to the eastward. On July 29–August 2, eight meteors observed at Bristol denoted the radiant at $34^\circ + 54^\circ$, and on August 6, six meteors fixed it at $40^\circ + 55^\circ$. On August 12 it was in $48^\circ + 57^\circ$ and on August 14 in $50^\circ + 56^\circ$.

Several remarkable meteors with very slow motion, and leaving trains of sparks, were recorded on August 12. One of the most striking of these appeared at 12h. 31m. It was of the 1st mag., and traversed a path of 33 degrees from $341^\circ + 81^\circ$ to $124^\circ + 64^\circ$ in about seven seconds. As it fell almost perpendicularly down the northern sky the nucleus poured out a stream of yellow sparks. Probably the radiant was near the southern horizon, and it is hoped that other observers will send in reports of this curious meteor, and enable its true radiant to be found.

Altogether the display seems to have been of average importance, and to have fallen below the observed strength of the shower on August 11, 1898. Many of the minor showers of the period made themselves apparent, though they were generally very feeble. The principal of them were at $41^\circ + 20^\circ$, $333^\circ + 26^\circ$, 345 ± 0, $315^\circ + 77^\circ$, $339^\circ - 11^\circ$ and $17^\circ + 31^\circ$. It is to be hoped that at places where the photographic method has been applied the results have been successful.

W. F. DENNING.

UNITED STATES DEEP-SEA EXPLORING EXPEDITION.

THE announcement that the U.S. Fish Commission steamer, *Albatross*, would shortly be despatched on an exploring expedition to the Pacific Ocean, has already been noticed in these columns. Particulars of the main objects of the expedition, and the route to be followed, are given by Mr. H. M. Smith in the *National Geographic Magazine*, from which the subjoined account has been abridged.

The *Albatross* is the best-equipped vessel afloat for deep-sea investigation, for which work she was especially constructed for the Fish Commission in 1882, at a cost of nearly 200,000 dollars. She is a twin-screw steamer of 384 tons burden, 234 feet long and $27\frac{1}{2}$ feet beam. A full account of the construction of the *Albatross* and her appliances for marine investigation has been given in the admirable work on "Deep-sea Exploration," by Commander Z. L. Tanner, U.S.N., under whose direction the vessel was built and who was in command from the date of her launching until 1894. The reputation long enjoyed by the *Albatross* of being unequalled in effectiveness for marine research will be more than ever deserved on the approaching cruise because of the extensive improvements and repairs she has recently undergone, including the installation of new boilers, ice-making machine, cold-storage plant, &c., together with the thorough replenishing of the scientific outfit.

The *Albatross* will pass through the Golden Gate on August 21 and begin her long voyage to certain groups of islands in the middle of the Pacific Ocean, both north and south of the equator, whose local fauna is almost unknown, while in the adjacent waters little or no scientific investigation has been carried on. The Society islands will be first visited, although the vessel will touch at the Marquesas islands for coal. Between San Francisco and Tahiti, a distance of 3500 miles, dredging and sounding will be carried on at regular intervals on a section of the sea-bottom almost wholly unexplored. Tahiti will be the headquarters while the Society islands and the Paumota islands are being explored. In the latter archipelago, which is about 600 miles long, six or eight weeks will be spent and important scientific discoveries should be made. In the Tonga or Friendly islands, distant about 1500 miles from the Society group, a week or ten days will be passed. The vessel will then proceed to the Fiji islands, where a short stay will be made, and thence 1700 miles to the Marshall islands, in which interesting archipelago, of whose natural history almost nothing is known, six or seven weeks will be devoted to exploration. The Ellice and Gilbert islands, lying between the Fiji and Marshall islands, will also be visited. It was originally the intention to have the *Albatross* proceed from the Marshall islands to the Hawaiian islands and thence to San Francisco, running a line of deep-sea dredgings along the entire route; but, owing to the prevalence of head winds at the time when the vessel will be ready to leave the Marshall islands, this plan has been abandoned, and instead the vessel will sail for Japan, making frequent use of the dredge and the deep-sea tow-net and setting the trawl in the moderately deep water off the Japan coast, where the fishermen are continually bringing up curious forms. The voyage of nearly 20,000 miles will come to an end at Yokohama, where the *Albatross* will arrive in April 1900, and refit for a summer cruise to Alaska to resume the systematic examination of the salmon streams begun several years ago.

The leading features of the expedition will be deep-sea dredging, trawling, and sounding, and some special appliances for such work have been constructed. A wire dredge-rope 6000 fathoms long has been made to order, and to accommodate this enormous quantity a special drum has had to be prepared. It is expected that both the dredge and the beam-trawl will be hauled in deeper water than heretofore. One of the novel pieces of collecting apparatus is a beam-trawl of unprecedentedly large size, especially designed for the capture of larger animals than can be taken with the usual apparatus.

While the deep-sea investigations will receive the most attention, surface and intermediate towing, shore-seining, and fishing trials with lines, gill-nets, and other appliances will be regularly carried on and will undoubtedly yield rich collections. The region to be visited abounds in atolls and elevated reefs, many of which will be visited and studied for the purpose of obtaining data bearing on the disputed question of the origin of coral reefs.

The *Albatross* is manned by about ten officers and seventy petty officers and enlisted men of the United States Navy. The commanding officer is Lieutenant Commander Jefferson F. Moser, U.S.N. The civilian staff on this expedition consists of Prof. Alexander Agassiz, in charge of the scientific work, who will be accompanied by his son and his personal assistants; Dr. W. McM. Woodworth and Dr. A. G. Mayer, of the Museum of Comparative Zoology, Cambridge, Mass.; Dr. H. F. Moore, chief naturalist of the *Albatross*; Mr. Charles H. Townsend, formerly naturalist, now chief of the fisheries division of the U.S. Fish Commission; Mr. A. B. Alexander, fishery expert, and Mr. H. G. Fassett, photographer, both of the U.S. Fish Commission.

Opportunity will undoubtedly be afforded for conducting a number of important collateral inquiries without detriment to the regular scientific work. Advantage will be taken of every chance to obtain for the National Museum specimens of the mammals, birds, insects, and other land animals of the various islands visited. A study of the aboriginal fishing methods, apparatus, and boats, and the collection of specimens of the native fishing appliances will be in charge of the fishery expert.

The Smithsonian Institution has specially requested that the Fish Commission make an effort to trace the origin of some of

the ethnological specimens brought back from the Pacific islands by the Wilkes Exploring Expedition. Commissioner Bowers has notified the Smithsonian Institution that the naval and civil attachés of the vessel will be given special instructions to be on the look-out for desirable ethnological material.

There is every reason to believe that this expedition will yield valuable scientific results, and will be creditable to the United States. It is the most important marine expedition on which the Fish Commission has embarked, and one of the most promising scientific enterprises in which the U.S. Government has ever engaged. It is a matter for congratulation that, in the activity in exploration of the seas now being exhibited by various Governments, the United States will participate under such favourable auspices and be represented by a man of science of such wide experience in deep-sea investigation as Prof. Agassiz.

MAGNETO-OPTIC ROTATION AND ITS EXPLANATION BY A GYROSTATIC SYSTEM.[1]

THE action of magnetism on the propagation of light in a transparent medium has been rightly regarded as one of the most beautiful of Faraday's great scientific discoveries. Like most important discoveries it was no result of accidental observation, but was the outcome of long and patient inquiry. Guided by a conviction that (to quote his own words) "the various forms under which the forces of matter are made manifest have one common origin," he made many attempts to discover a relation between light and electricity, but for very long with negative results. Still, however, retaining a strong persuasion that his view was correct, and that some such relation must exist, he was undiscouraged, and only proceeded to search for it more strictly and carefully than ever. At last, as he himself says, he "succeeded in *magnetising and electrifying a ray of light, and in illuminating a magnetic line of force.*"

Faraday pictured the space round a magnet as permeated by what he called lines of force; these he regarded as no mere mathematical abstractions, but as having a real physical existence represented by a change of state of the medium brought about by the introduction of the magnet. That there is such a medium surrounding a magnet we take for granted. The lines of force are shown by the directions which the small elongated pieces of iron we have in iron filings take when sprinkled on a smooth horizontal surface surrounding a horizontal bar magnet, as in the experiment I here make. [*Experiment to show field of bar magnet by iron filings.*]

The arrangement of these lines of force depends upon the nature of the magnet producing them. If the magnet be of horse-shoe shape, the lines are crowded into the space between the poles; and if the pole faces be close together and have their opposed surfaces flat and parallel the lines of force pass straight across from one surface to the other in the manner shown in the diagram before you. [*Diagram of field between flat pole faces.*]

The physical existence of these lines of force was demonstrated for a number of different media by the discovery of Faraday to which I have already referred, and on which almost all the later work on the relation of magnetism to light has been founded. I am permitted by the kindness of the authorities of this Institution to exhibit here the very apparatus which Faraday himself employed, though for the various experiments I have to make it is necessary to actually use another set of instruments. [*Apparatus shown.*] Before repeating Faraday's experiment, let me describe shortly what I propose to do, and the effect to be observed.

A beam of plane polarised light is produced by passing white light from this electric lamp through a Nicol's prism. To understand the nature of plane polarised light, look for a moment at this other diagram (Fig. 1). It represents a series of particles displaced in a certain regular manner to different distances from the mean or equilibrium positions they originally had along a straight line. They are moving in the directions shown by the arrows and with velocities depending on their positions, as indicated by the lengths of the arrows. Suppose a certain interval of time to elapse. The particles will have moved in that time to the positions shown in this other diagram (Fig. 2) on the same sheet. It will be seen that the velocities as well as the positions of the particles have altered; but that the configuration is the same as would be given by the former diagram moved through a certain distance to the left.

Thus an observer looking at the particles and regarding their configuration would see that configuration apparently move to the left; and this, it is very carefully to be noted, is a result of the transverse motions of the individual particles. In another interval of time equal to the former the arrangement of particles will appear to have moved a further distance of the same amount towards the left.

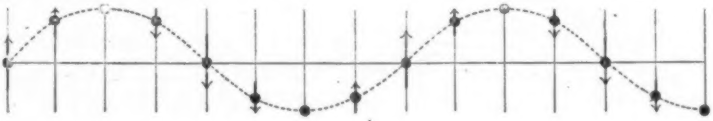


FIG. 1.

This transverse motion of the particles, thus shown displaced from their equilibrium positions, represents the vibration of the medium which is the vehicle of light, and the right to left motion of the configuration of particles is the wave motion resulting from that vibration. I do not say that the medium is thus made up of discrete particles, or that the different portions of it vibrate in this manner, but there is undoubtedly a directed quantity transverse to the direction in which the wave is travelling, the value of which at different points may be represented by the displacements of the particles, and which varies in the same manner, and results, as here shown, in the propagation of a wave of the quantity concerned.

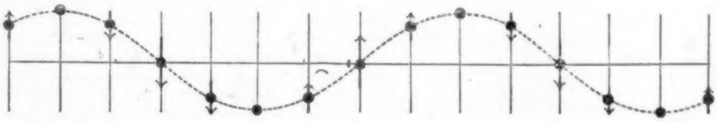


FIG. 2

In fact, we have here a representation of a wave of plane polarised light. The directions of vibration are right lines parallel at all points along the wave. Ordinary light consists of vibrations the directions of which are not parallel if rectilinear, and each vibration is therefore capable of being resolved into two in directions at right angles to one another. The Nicol's prism, in fact, splits a wave of ordinary unpolarised light into two waves, one in which the vibrations are in one plane containing the direction in which the light is travelling, the other in a plane containing the same direction, but at right angles to the former. One of these waves is stopped by the film of Canada balsam in the prism and thrown out of its course, while the other wave is allowed to pass on undisturbed.

If the wave thus allowed to pass by one Nicol's prism be received by another it is found that there are two positions of the latter in which the wave passes freely through the second

[1] A discourse delivered at the Royal Institution by Prof. Andrew Gray, F.R.S.

prism, and two others in which the wave is stopped. The prism can be turned from one position to another by properly placing it and then turning it round the direction of the ray. It is found that if the prism be thus turned from a position in which the light is freely transmitted we come after turning it through 90° to a position in which the light is stopped, and that if we go on turning through another angle of 90° a position is reached in which the light is again freely transmitted, and so on, the light being alternately stopped and transmitted by the second prisms in successive positions 90° apart.

The mode of passage of the wave by the Nicols when their planes are parallel, and its stoppage when the planes are crossed, are illustrated by this diagram (Fig. 3) of a vibrating cord and two slits. When the slits are parallel, the vibration

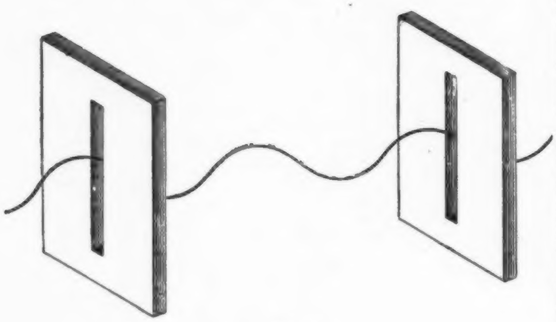


FIG. 3

which is passed by one is passed by the other; when they are crossed, a vibration passed by one is stopped by the other.

Two planes of symmetry of the prisms parallel to the ray, and called their principal planes, are parallel to one another when the light passes through both, and are perpendicular to one another when the light passed by the first is stopped by the second. We shall call the first prism the polarising prism, or the *polariser*, from its effect in producing plane polarised light; the other, the *analyser*. The stoppage of the light in the two positions 180° apart of the second prism and its passage in the two intermediate positions show that the light passed by the first prism is plane polarised.

Now a beam of plane polarised light is passed through the perforated pole-pieces of this large electro-magnet (Fig. 4), so

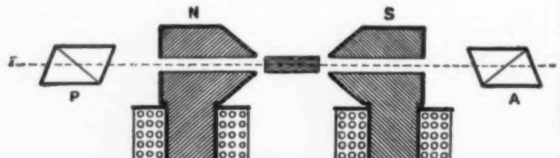


FIG. 4.

that the beam travels between the pole faces along the direction which the lines of force there would have if the magnet were excited by a current. The arrangement of the apparatus is as shown in the diagram. The light is polarised by the prism P, passes through the magnetic field, and then through the analysing prism A, to the screen. As you see, when the second prism is turned round the ray the light on the screen alternately shines out and is extinguished, and you can see also that the angle between the positions of free passage and extinction is 90°.

I now place in the path of the beam this bar of a very remarkable kind of glass, some of the properties of which were investigated by Faraday. It is a very dense kind of lead glass, which may be described as a silicated borate of lead; that is, it contains silica, boric acid and lead oxide. The beam is not disturbed although the light passes through the glass from end to end. I now adjust the analysing prism to very nearly complete extinction, and then excite the magnet. If the room is sufficiently darkened I think all will see that when the magnet is excited there is a very perceptible brightening of the dim patch of light on the screen, and that this brightening disappears when the current is removed from the magnet. This is Faraday's discovery.

How are we to describe this result? What effect has been produced by the magnetic field? It is clear that the direction of vibration of the light emerging from the specimen of heavy glass has been changed relatively to the prism so that the light now readily passes. It is found, moreover, that the amount of turning of the direction of vibration round the ray is proportional to the length of the specimen, so that the directions of vibration at different points along the wave within the specimen lie on a helically twisted surface, and may be regarded as represented by the straight rods in the model before you on the table (Fig. 5).

It is also found that the amount of the turning depends on the intensity of the magnetic field—is, in fact, simply proportional to that intensity. Hence the turning is proportional to the mean intensity of the field, and to the length of the path in the medium, that is, to the products of these two quantities. It also depends on the nature of the medium. The angle of turning produced by a field of known intensity when the ray passes through bisulphide of carbon has been very carefully measured by Lord Rayleigh, whose results are of great value for other magnetic work.

The law of proportionality of the amount of turning of the plane of polarisation to the intensity of the magnetic field in

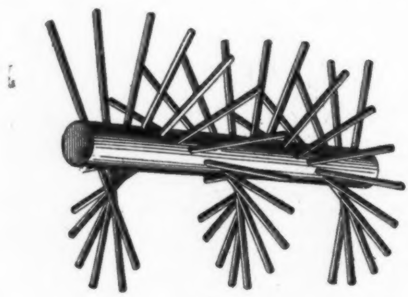


FIG. 5.

the space in which the substance is placed is not, however, to be regarded as established for strongly magnetic substances, such as iron, nickel or cobalt. The matter has not yet been completely worked out, but the turning in such cases seems to be more nearly proportional to the intensity of magnetisation, a different quantity from the intensity of the magnetic field producing the magnetisation. If this law be found correct the angle of turning will be proportional to the product of the intensity of magnetisation and to the length of the path; and the angle observed divided by this product will give another constant, which has been called Kundt's constant.

The rotation of the plane of polarisation in strongly magnetised substances was investigated by Kundt, the very eminent head of the Physical Laboratory of the University of Berlin, who died only a year or two ago. Kundt is remembered for many beautiful methods which he introduced into quantitative physical work; but no work he did was more remarkable than that which he performed in magneto-optic rotation when he succeeded in passing a beam of plane polarised light through plates of iron, nickel and cobalt. Such substances, though apparently opaque to light, are not really so when obtained in plates of sufficient thinness. In sufficiently thin films all metals, so far as I know, are transparent, not merely to Röntgen rays, but to ordinary light. Kundt conceived the idea of forming such films of the strongly magnetic metals, so as to investigate their properties as regards magneto-optic rotation. He succeeded in obtaining them by electroplating platinised glass with such thin

stratums of these metals that light passed through them in sufficient quantity for observation. The rotation produced by the glass and the exceedingly thin film of platinum was determined once for all and allowed for. Kundt obtained the remarkable result that the magnetic rotatory power in iron is so great that light transmitted through a thickness of one centimetre of iron magnetised to saturation is turned through an angle of over 200,000°, that is, that light passing through a thickness of an inch of iron magnetised to saturation would have its plane of polarisation turned completely round more than a thousand times; in other words, one complete turn would be given by a film less than $\frac{1}{1000}$ of an inch in thickness. A scarcely smaller result has been found by Du Bois for cobalt, and a maximum rotation of rather less than half as much by the same experimenter for nickel.

The direction of turning in all the cases which have so far been specified—that is, Faraday's glass, bisulphide of carbon, iron, nickel and cobalt—is the same as that in which a current of electricity would have to flow round the spires of a coil of wire surrounding the specimen so as to produce the magnetic field. This we call the *positive* direction. There are, however, many substances in which the turning produced by the magnetic field is in the contrary or negative direction; for example, ferrous and ferric salts of iron, chromate and bichromate of potassium, and in fact most compound substances which are feebly magnetic.

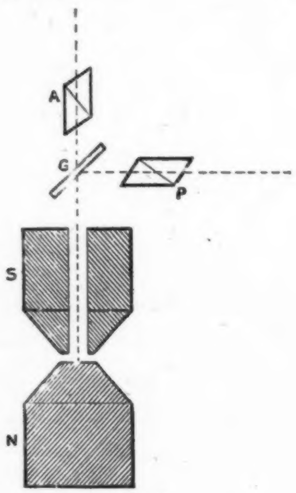


FIG. 6.

Faraday established by his experiments the fact that substances fall into two distinct classes as tested by their behaviour under the influence of magnetic force. For example, an elongated specimen of iron, nickel or cobalt, if freely suspended horizontally between the poles of our electro-magnet, would set itself with its length along the lines of force. On the other hand, a similar specimen of heavy glass, or a tube filled with bisulphide of carbon, would, if similarly suspended, set itself across the lines of force. The former substances were therefore called by Faraday paramagnetic, the latter diamagnetic.

It might be supposed that diamagnetics would show a turning effect opposed to that found in paramagnetics, but this is not the case. As we have seen, bisulphide of carbon and heavy glass, which are diamagnetics, show a turning in the same direction as that produced in iron—as indeed do most solid, fluid and gaseous diamagnetics. Feebly paramagnetic compound substances, on the other hand, produce negative rotation.

A theory of diamagnetism has been put forward in which the phenomena are explained by supposing that all substances are paramagnetic in reality, but that so-called diamagnetic bodies are less so than the air in which they are immersed when experimented on. Thus the diamagnetic quality is one of the substance relatively to air, in the same kind of way as the apparent levity of a balloon is due to the fact that its total weight has a positive value, but is less than that of the air displaced by the balloon and appendages. Lord Kelvin's dynamical explanation of magneto-optic rotation does not bear out this view of the matter.

Before passing to the dynamical explanation, however, I must very shortly call attention to some remarkable discoveries in this subject made by Dr. John Kerr, of Glasgow. I have here an electro-magnet arranged as in the diagram before you (Fig. 6). The light from the lamp is first plane polarised by the Nicol P, then it is thrown on the piece of silvered glass G, and part of it is thereby reflected through this perforated pole-piece so as to fall normally on the polished point of the other pole-piece. Reflection thus takes place at perpendicular incidence, and the reflected light is received by this second Nicol. When the magnet is unexcited the second Nicol is arranged so as to quench the reflected light. The magnet is then excited, and it is found that the light is faintly restored, showing that an effect on the polarisation of the light has been produced by the magnetisation. It is to be noticed here that the incident and reflected light is in the direction of magnetisation. We shall not pause to make this experiment. It was arranged this morning and successfully carried out; but the effect is slight, and might not be noticeable without precautions, which we have hardly time to make, to exclude all extraneous light from the screen.

It would perhaps be incorrect to say that the plane of polarisation has been rotated in this case, as it has been asserted by Righi that the light after reflection is no longer plane polarised, but that there are two components of vibration at right angles to one another, so related that the resultant vibration is not

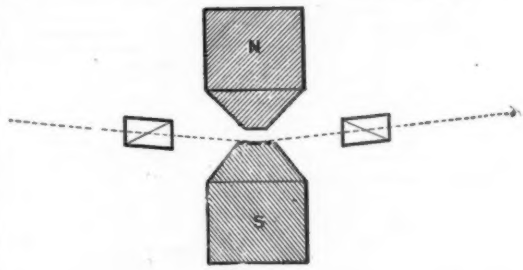


FIG. 7.

rectilinear but elliptical. There is therefore no position in which the analysing prism can be placed so as to extinguish the reflected light. The transverse component necessary to give the elliptic vibration is, however, in this case, if it exists, very small, and very nearly complete extinction of the beam can be obtained by turning the analysing prism round so as to stop the other component vibration. The angle through which the prism must be turned to effect this is the amount of the apparent rotation. The direction of rotation is reversed by reversing the magnetism of the reflecting pole. Dr. Kerr found that the direction is always that in which the current flows in the coils producing the magnetisation of the pole.

Dr. Kerr also made experiments with light obliquely incident on a pole-face, with the arrangement of apparatus shown in this other diagram (Fig. 7). He found that the previously plane polarised light was by the reflection rendered slightly elliptically polarised. A slight turning of the analysing Nicol was necessary to place it so as to stop the vibration corresponding to the long axis of the ellipse and so secure imperfect extinction.

These effects are, like those of normal incidence, very small, and they can hardly be shown to an audience.

(To be continued.)

SCIENCE SCHOOLS AND CLASSES.[1]

THE annual Report of the Department of Science and Art furnishes much information on the progress made in elementary scientific instruction year by year; and the following facts, derived from the Report just published, shows the vast extent of the Department's operations during 1898. The number of students under instruction in schools eligible for the

[1] Forty-sixth Report of the Department of Science and Art of the Committee of Council on Education, with appendices. Pp. 320. (H.M. Stationery Office, 1899.)

Department's grants in that year was 158,370. These students were distributed among 11,723 classes in 2023 different schools. Scotch schools and students are not included in these figures, the Scotch Education Department having taken over the administration of grants for science and art instruction. Even more satisfactory than the increase of the number of pupils receiving science instruction is the fact that in 1898 there were 159 Schools of Science—that is, schools following an organised course of scientific instruction—in which practical work forms an essential part. The number of students in these schools was 21,193. This is a considerable increase on the preceding year, when the number of Schools of Science was 143, with 18,142 students.

For the year 1898 the grants to science schools in England, Wales and Ireland, exclusive of those made to training colleges, amounted to 169,604*l.* 3*s.* 3*d.* The sum included (*a*) 85,862*l.* to science schools for attendance grants, and 614*l.* on results of examination (honours only); total, 86,476*l.*; (*b*) 82,998*l.* to Schools of Science, for capitation and attendance grants and grants on results of examination.

The figures under (*a*) show an average payment in 1898 of 12*s.* 7½*d.* for each individual student under instruction in science schools, whilst the average payment per student under instruction in Schools of Science (*b*) was 3*l.* 18*s.* 2*d.*

The grants now made to schools are based upon the attendance of pupils, instead of being computed on the results of the individual examinations. Referring to this change and to the increase of practical work, Captain Abney, the Director for Science, says:—"In the past year, the system of payments by attendance was made general to all schools except in the case of Schools of Science. From this mode of payment candidates for honours were necessarily omitted, their work being necessarily special and requiring special treatment. The abolition of payments on results has diminished to some extent the numbers of students who were presented for examination, and the course of instruction in the various stages of the subjects of science for which payments are made will be more prolonged. This undoubtedly tends to sound instruction. . . . There is a decided increase in practical instruction in various subjects, and in many places laboratories for physics and for biological subjects have been provided, as the higher attendance grant is only attainable where such provision has been made. I cannot help commenting upon the very marked impression that the obligation to give practical instruction in science has made in the elaboration of apparatus for teaching purposes. At a conference on science teaching, held at the Chelsea Polytechnic under the auspices of the London Technical Education Board, there was an exhibition and demonstration of the use of science apparatus in teaching. The novelties in apparatus and the general interest taken in the conference by science teachers and others clearly indicated the rapid advances that had been made in this branch of teaching."

The Reports of the Inspectors of the Department include many points worthy of the consideration of educationists. The following extracts contain a few of the views expressed on the general subjects of secondary schools and science teaching; and as they represent opinions based upon direct experience of the conditions of elementary scientific instruction in this country, they have exceptional value.

Extracts from Reports.

Many of the smaller secondary schools are still badly equipped for teaching purposes. Most of them are ill-supplied with funds, and have consequently an inadequate and inferior staff of teachers, while some few are bent upon continuing methods and subjects of instruction which must be of little value to the class from which their pupils should be drawn. It is, moreover, impossible to deny that owing to the practical absence of outside criticism some few secondary schools are hopelessly inefficient. . . . Many country grammar schools have reason to be thankful to the County Councils for the very liberal aid they have received towards the erection or equipment of suitable rooms for science purposes, or towards the payment of a science master. The County Councils can for their part in most cases ensure that the science work is thoroughly and systematically given by requiring the school to place itself in connection with the Department. To this the best and most progressive of the smaller schools offer no objection. They realise that assistance from public funds must be accompanied by some amount of public control, and as a rule the visit of the inspector is most feared where it is most unknown. Still, in spite of County Council assistance and Department grants, many of the endowed grammar schools are still in straitened circumstances. Where fees are low and endowments small, it is often a serious matter to secure a proper staff of teachers, to keep fittings and apparatus in a proper state of completeness, and to provide for the necessary outlay on repairs, rates and taxes. It is therefore not a matter for surprise if the science and art appliances in some of the secondary schools are found to be meagre in quantity and poor in quality.

On the whole, it may be said that a very fair provision has been made for scientific and technical instruction of the youth of the country up to, at any rate, the age of sixteen or seventeen, supposing them to devote themselves to study until attaining that age, and that in most large towns the artisan and manufacturer can obtain good instruction in technology and general science. But our larger polytechnics could be much further utilised if research work in their laboratories were more encouraged.

It would be most helpful to the technical education of the country if a fairly liberal grant could be paid on any student who, having acquired sufficient training in science, devoted himself to some special work in a laboratory under the supervision of the teacher in charge. The results of such work might be examined and criticised by the professors and examiners of the Department, and, if worthy, brought to the notice of the various societies for the promotion of scientific investigation.

The freedom from examination in the elementary courses of Schools of Science has had considerable influence on the character of the teaching, especially in the practical work. Teachers have awakened to the fact that science may afford a sound mental training, and that method is no less important to a student than results. Syllabuses exhibit a more logical sequence. Instead of depending upon a course thought out by others, teachers are beginning to think out their own, and although there is room for improvement, enlightened methods are making way. The "Heuristic method," which seeks to make each boy or girl a "discoverer" of known physical laws, and thus develop in him the scientific spirit, has had an important influence on the teaching of science. In the hands of a highly competent teacher it is an important guiding principle—in the hands of some of its disciples there is danger of its becoming a fetish. The Heuristic method is essentially historical; the pupil is told little, but is put in the way of finding out for himself, which is well. But there is as much danger in telling him too little as in telling him too much. It is not perhaps impertinent to point out that scientific discoveries have seldom been inductive. Investigators have been acquainted with the results of other discoverers, and have had, almost invariably, a "working hypothesis" which they have sought to establish by deductive methods. It is therefore advisable to lay stress on the usefulness in teaching science of a "working hypothesis," which should form the basis of practical work having for its object the "discovery" of a law. Though the beginner "must be put in the position of an original discoverer," it should be borne in mind that an original discoverer has at his disposal the observations and views of other investigators. It is only fair that the student should be placed in pretty much the same position, otherwise his observations will be ill-directed, and will lead him nowhere. It is almost needless to remark that in any case the advanced work may be more didactic.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE natural history collections in the Whitechapel Public Library and Museum are being systematically used by many teachers in the elementary schools of the district to illustrate object lessons. Teachers who propose to utilise the collections for this purpose send to the curator, Miss Kate M. Hall, a list of the object lessons they are giving, and arrangements are then made for one or more practical demonstrations bearing upon the lessons. The children (about forty-five in number) are brought up to the museum every week, for 1 to 1½ hours, until the course is finished. They are divided into three groups of fifteen, and each group spends about twenty minutes at each table on which the specimens chosen for the lesson have been placed. In this way the children have the opportunity of closely observing the objects, and of comparing the structure

with that of other animals or plants. By this means the Library Commissioners are making the collection of real service in elementary education.

THE Scottish Education Department has formulated a scheme whereby an agricultural college is to be instituted, to take over the functions of the agricultural department of the Glasgow and West of Scotland Technical College and the Kilmarnock Dairy School. The special grant of 2000*l.* voted for agricultural education in Scotland, and now administered by the Scotch Education Department, has been distributed in various amounts to four institutions, two being those mentioned and the two others the Edinburgh School of Rural Economy and the Agricultural Department of Aberdeen University. It has, however, long been felt that the grants to these institutions ought to be reinforced by contributions from local authorities in order to place the institutions in a position to exercise a more decided influence upon the progress of agriculture in Scotland than has yet been possible. Several County Councils having recently promised support, in some cases of a very substantial kind, to an independent agricultural college in the West of Scotland, the Scotch Education Department prepared a scheme for such an institution, and it has been accepted by the various bodies concerned. The college will give facilities for the most thorough and highly developed instruction in agriculture to those students who are able to devote a considerable time to this study, and should at the same time be a means of bringing home to the agricultural population of the districts concerned the latest results of agricultural research.

THE degree of Doctor of Philosophy was conferred in 1898 upon 224 candidates by twenty-three universities in the United States. An analysis of the statistics referring to these doctorates is given in *Science*, together with the names of those who received the degree in science, and the titles of their theses. Of the 224 degrees, 72 were in the humanities (under which are included philology, grammar, literature and philosophy), 37 were in history and economics, and 115 in the sciences. Six universities, Johns Hopkins, Columbia, Yale, Chicago, Harvard and Pennsylvania, conferred 169 degrees—more than three times as many as all the other United States universities combined. Columbia gave this year decidedly the largest number of degrees in the sciences, while Harvard is the only one of these universities in which the degrees in the humanities were more numerous than in the sciences. The distribution of students among the different sciences was as follows:—Chemistry, 32; psychology, 15; mathematics, 13; botany, 11; zoology, 11; physics, 7; education, 5; geology, 5; sociology, 5; palæontology, 4; astronomy, 2; mineralogy, 2; physiology, 1; bacteriology, 1; meteorology, 1. It will be noticed that chemistry leads very decidedly. While no definite conclusion can be drawn from the results, it may be noted that at Johns Hopkins more than half the scientific degrees are given in chemistry. This science also leads at Yale and Harvard. Psychology and education are especially strong at Columbia. Chicago stands first in zoology and in physiology.

THE Technical Instruction Committee of the Oxfordshire County Council have presented their annual report on the work of the schools and institutions aided by them during the past year. The Committee has been recognised by the Department of Science and Art as the organisation responsible for science and art instruction within its area. No grants will therefore be made by the Department to the managers of new schools and classes unless they are acting in unison with the Committee. The managers of all the schools and classes in the county which are receiving Science and Art grants have agreed to come within the new organisation. With regard to rural agricultural instruction, the Committee report that at the Chipping Norton Agriculture Class, under Mr. W. Warne, there were seventy-six students, of an average age of 39·5. They were factory hands, labourers, mechanics and small tradesmen, who all cultivated allotments. One thousand and twenty attendances were made at twenty-four meetings. The subject of the course was "Insects as friends and foes to agriculture." To illustrate how agriculture is being gradually developed by the work of the science lecturers, the Committee report that from advice given by Mr. Stewart, at Minster Lovell, in his lectures, an acre of strawberries was planted. This year a much larger area was laid down there. It is hoped that an industry in soft fruit is now started in that locality. At the same place a fruit farm of three acres was laid out two years ago on Mr. Stewart's advice. It was so successful that now twelve acres are laid out. At Stoke Row, eight tons of filberts last year were saved by the treatment given to the nut weevil, and last year the currant bushes were afflicted by the currant mite, but spraying the bushes enabled four tons to be marketed. Codlin moth and apple-blossom weevil attacked the apple trees, but Mr. Stewart's treatment saved the trees. When agriculturists are brought in this way to see the practical side of scientific knowledge they begin to understand the value of the science of agriculture.

SCIENTIFIC SERIALS.

American Journal of Science, July.—Velocity of electric waves in air, by G. V. Maclean. The author describes an elementary type of coherer suitable for the Hertzian experiment of determining wave-lengths from nodes produced by metallic reflection. It consists of two globules of platinum, 1 mm. in diameter, attached to the ends of two platinum wires forming spirals about two iron terminals which run through the centre of the two brass caps of a glass tube 8·5 cm. long. The globules can be adjusted to any small distance from each other. The velocity of propagation, determined from the wave-length and the period of oscillation, is $2·991 \times 10^{10}$ cm. per second, or practically the same as along wires.—Spiral fulgurite from Wisconsin, by W. H. Hobbs. A lightning tube forming a perfect dextrorotary helix has recently been presented to the geological collection of the University of Wisconsin. It was found embedded in a sand knoll about ten feet high, at a distance of five feet below the surface. The tube is as thick as a man's thumb, and five inches long. The fulgurite from Waterville, Maine, described by Bayley in 1892, also shows a dextrorotary structure. The author suggests that this twist is somehow connected with the electrical conditions under which the tubes were produced, and guesses at an influence of the earth's magnetic field upon the path of the lightning.—The mouth of Grand River, by E. H. Mudge. The mouth dealt with is not the present Grand Haven, but another point seventy miles inland from the shores of Lake Michigan, which was the termination of the old river valley. At one time a great glacial stream, three-fourths of a mile in width, flowed across the peninsula from Lake Saginaw to Lake Chicago. This stream has been called the Pewamo outlet. The author describes its course and the river-mouth deposits about the old mouth.—Electrical measurements, by H. A. Rowland and T. D. Penniman. The authors have tested six out of the thirty different methods of measuring self-induction and capacity indicated by Rowland. The methods for the comparison of the two self-inductions, or a self-induction and a capacity, are independent of the period of the alternating current used, and an accuracy of 1 in 10,000 can be attained.—Reflection of Hertzian waves at the ends of parallel wires, by L. de Forest. The author uses a compromise between the Lecher and the Blondlot wire systems, and investigates the relation between the change of phase in reflection from bare ends of various shapes, and the frequency.

Wiedemann's Annalen der Physik und Chemie, No. 6.—Observation of fringes in the development of Daguerre plates with wedge-shaped silver iodide layers, by O. Wiener. A silver plate was iodised in two wedge-shaped layers by laying it on a glass tube during exposure to the iodine vapour, the layer thus being made to increase in thickness from the line of contact outwards. A spectrum with the slit normal to the lines of equal thickness was then photographed on the plate, and it was found that the sensitiveness varied periodically with the thickness, maxima occurring whenever the surface coincided with a ventral segment of the electrical force, produced by reflection at the boundary dividing the iodide from the metallic silver.—Experiments on certain flow formations, by K. Mack. Deals with the deformations of fungoid flow structures by gravitation, and the deformation of horizontal layers of liquid by ascending fungoid structures.—Influence of gaseous pressure upon electric currents due to Röntgen rays, by W. Hillers. Near the pressure at which the gaseous resistance reaches a maximum, the current intensity varies as the square root of the pressure.—An electrolytic current interrupter, by A. Wehnelt. This is a reprint of the author's original paper from the *Elektrotechnische Zeitschrift*.—Action of the Wehnelt interrupter, by H. T. Simon. The author formulates what he claims to be a complete mathematical

theory of the Wehnelt interrupter. Between the period T and the E.M.F. E he obtains the relation

$$T = A + \frac{B}{E^2}$$

which is closely borne out by experiment.—Magnetic properties of the elements, by S. Meyer. The author attempts to connect the permeabilities of the elements in the pure state with their atomic weight. When arranged in periodic series, the paramagnetic elements are seen to group themselves in the centre, and the diamagnetic elements at the ends. The scheme is at present very rough, owing to the difficulty of determining the permeabilities of the rare elements.—Transverse tones of caoutchouc threads, by V. von Lang. When caoutchouc threads are stretched, the pitch of the note emitted by them remains constant between certain lengths, owing to the fact that the ratio of length to tension is constant. The author investigates how far Taylor's formula applies to such threads.—Accurate control of the frequency of an alternating current, by J. Zenneck. The alternate current is made to produce a rotary field, to which the kathode beam in a Braun tube is exposed. The end of the beam describes a circle on the screen, which is interrupted by a tuning-fork twice during every revolution. As long as the dots thus produced are on the same diameter the frequency is constant.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, August 7.—M. Maurice Lévy in the chair.—On rolling motion; equations of motion analogous to those of Lagrange, by M. Appell. The Lagrange equations cannot be applied without modification to those dynamical problems in which the relations between the solid bodies are such that they are allowed to roll or are pivoted on each other. In a system of three independent parameters q_1, q_2, q_3, the equations of motion are reduced to the form $\frac{\partial S}{\partial q_1} = Q_1$, where Q_1 is a function of the forces to which the bodies are submitted, and $S = \frac{1}{2}\Sigma m J^2$, J being the acceleration of the point *m*.—Thermochemical determinations: ethylenediamine, by M. Berthelot. Measurements are given for the heats of combustion and formation of cholalic acid, amygdalin, conicine, and ethylenediamine.—On ammoniacal silver nitrate, by MM. Berthelot and Delépine. A thermochemical study of the action of ammonia solution upon a solution of silver nitrate. The oxide of silver-ammonium is shown to be an alkali, with a heat of neutralisation comparable with those of the most energetic mineral alkalis.—On the expansion of iron and steel at high temperatures, by M. H. Le Chatelier. The table of expansions given for soft iron and six specimens of steel, at temperatures ranging between 0° and 700°, shows that the differences in the expansions of the various specimens are within the limits of experimental error; up to about 750°, iron and steel expand similarly. But above the temperature of molecular transformation the expansion of the different specimens of steel varies very rapidly with the amount of carbon present, an increase of carbon from 0·05 to 1·2 per cent. doubling the coefficient of expansion.—Action of chlorine on a mixture of silicon, silica, and aluminium, by M. Émile Vigouroux. A good yield of pure silicon tetrachloride may be obtained by first heating together a mixture of silica (200 gr.) and aluminium (100 gr.) to a dull red heat, cooling the mass and extracting with acids. The residue, thus freed from aluminium, contains from 14 to 22 per cent. of silicon, and readily gives the pure tetrachloride on treating with chlorine in the usual way.—Action of hydrogen phosphide upon copper oxide, hydrate and carbonate, by M. E. Rubénovitch. The reaction with the oxide is energetic, and takes place according to the equation

$$5PH_3 + 10CuO = 2P_2Cu_5 + H_3PO_4 + 6H_2O.$$

Copper hydrate behaves similarly, if the gas is admitted in such small quantities that the temperature of the reaction cannot rise to incandescence. With basic copper carbonate the reaction is

$$5PH_3 + 5CuCO_3.Cu(OH)_2 = 2Cu_5P_2 + H_3PO_4 + 5CO_2 + 11H_2O.$$

—On the estimation of mannose in admixture with other sugars, by MM. Em. Bourquelot and H. Hérissey. The authors apply the property possessed by mannose of giving an insoluble hydrazone in the cold to the estimation of this sugar. The numerous test analyses, some on pure mannose, others on mixtures of the same with galactose and maltose, are very satisfactory.—On some properties of dioxyacetone in respect to its molecular aggregation, by M. Gabriel Bertrand. Dioxyacetone appears to exist in two forms, one in crystals, having a molecular weight $2(C_3H_6O_3)$, which is practically insoluble in cold alcohol, ether, or acetone; the other, formed by simply melting the crystals, has the simple formula $C_3H_6O_3$, and is very soluble in these solvents. Water slowly dissociates the bimolecular form, but not so rapidly as to prevent cryoscopic measurements being made in confirmation of the above views.—On the variations in the production of glycerol during the alcoholic fermentation of sugar, by M. J. Laborde. In the numerous experimental results quoted, the glycerol found varied from 2·5 to 2·75 grams of glycerine per 100 grams of sugar decomposed. The same yeast, living in saccharine media of the same concentration of sugar, may give very varying amounts of glycerol, the production being in inverse proportion to the activity of the yeast. A rise of temperature favours an increase in the amount of glycerol.—On the anatomical structure of *Vanilla aphylla*, by M. Édouard Heckel. A comparison of the anatomical characters of the stems of *V. aphylla* and *V. phalaenopsis* shows such great differences that it is impossible to class them together in the same genus. The author also points out that the theory adopted by Herbert Spencer, in his "Principles of Biology," to explain the formation of monocotyledonous stems, is strongly supported by the fact of the simultaneous presence in the stem of *V. aphylla* and the leaves of *V. phalaenopsis* of the same cellular elements constituting the skin.—The *Piralahy*, the india-rubber weed of Madagascar, by M. Henri Jumelle.—On the external border of the Briançonnais between Freyssinières and Vars, by MM. W. Kilian and E. Haug.—On the pot-holes of the granitic islets of the cataract of Assouan, by M. Jean Brunhes.

CONTENTS.

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